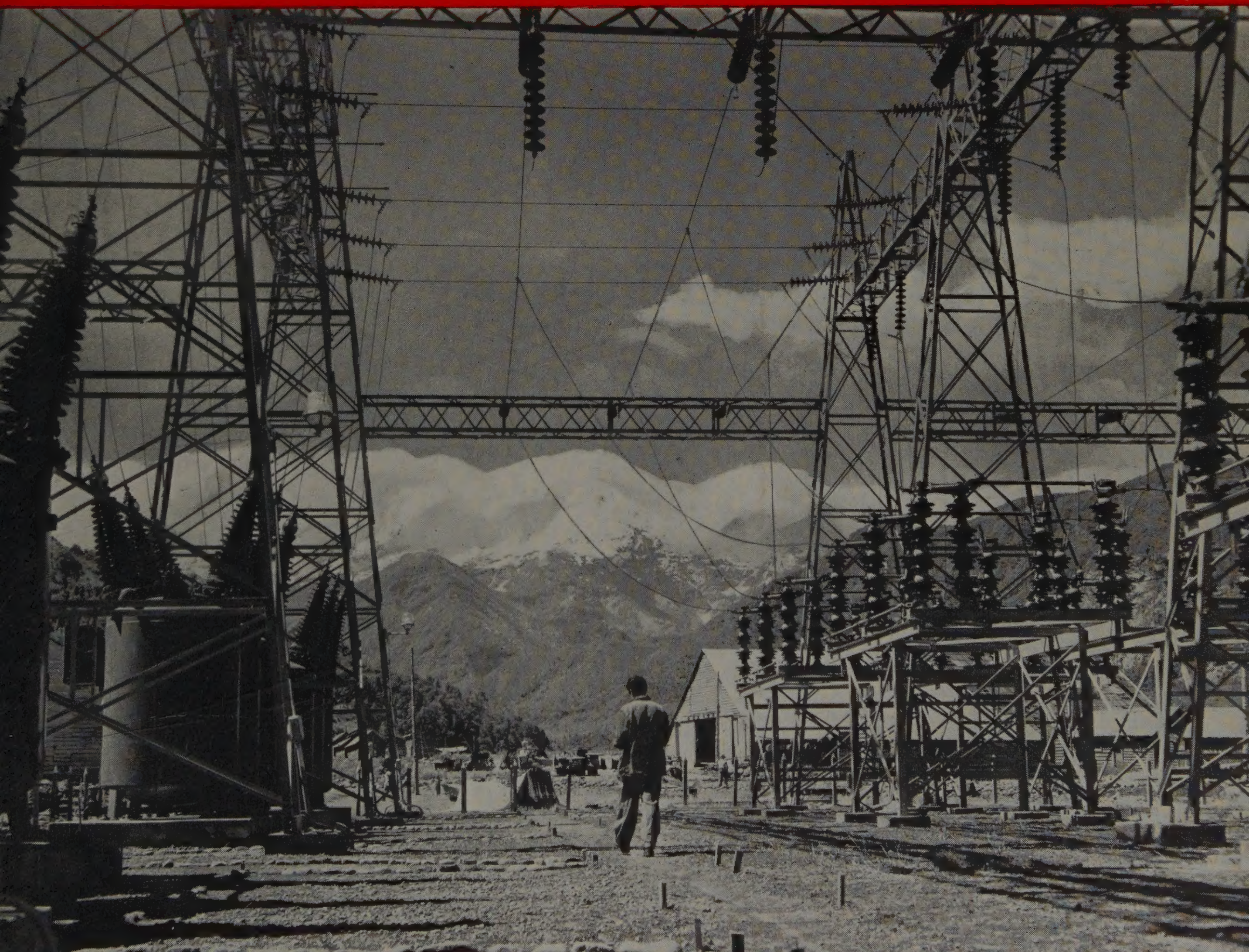
ELECTRICAL ENGINEERING

MARCH 1952



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The Cover: A view of the Sierra Velluda Mountains from the transformer banks of one of Chile's new hydroelectric stations located at Abanico. The station has a capacity of 120,000 kw. See story in "Current Interest" on page 299 of this issue.

TECHNICAL PAPER DIGESTS

VOL. 71 NO. 3

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HIGHLIGHTS........

Some Neglected Obligations. Engineers recognize that there are moral and spiritual laws quite as exacting as the physical laws, says AIEE President McMillan, and for our guidance in dealing with our fellow men AIEE has a "Statement of Principles of Professional Conduct" (*pages 201–03*).

The Challenge of the Future. There is a similarity between the position of the American scholar in 1837 and the position of the engineer and physical scientist of today, said Charles E. Wilson at the Winter General Meeting, and he quoted Ralph Waldo Emerson to show how this was so (*pages 203–06*).

Quiescent Current Compensation. Magnetic amplifier circuits for cascade connection require some method for annulling or compensating for the effects of quiescent current of one stage on the stages which follow so that the final stages will not be saturated when no signal is applied to the first stage. Some circuits for accomplishing this are discussed (*pages 206–11*).

Growth Engineers for a Growth Industry. For the electric utility industry to keep growing at the same rate of speed as in the past more management-trained engineers must be brought into the industry. This problem and possible solutions are discussed by the author (*pages 213–14*).

The Edison Medal. Charles F. Wagner was awarded the 1951 Edison Medal at the General Session of the AIEE Winter General Meeting. Full texts of the presentation and acceptance addresses of Mr. Wagner, A. C. Monteith, who gave the career and achievements of the Medalist, and J. F. Calvert, who spoke briefly on the history of the Edison Medal, are given in this issue (*pages 216–19*).

The Series Capacitor in Sweden. The installation of a series capacitor in one of Sweden's major transmission lines has been so successful that this type of compensation is being considered for most of the future additions to that country's high-power network. Some of the economic and technical problems of the first installation are discussed (*pages 222–27*).

Series Capacitors at Bonneville. Some of the important features of the first series capacitor installations in the United States on a 230-kv system are described to contrast it with the Swedish installation. For example, the Bonneville installation uses means for quick reinsertion, while the Swedish capacitor does not (*pages 228–32*).

Radio Dispatching for Taxicabs. There are approximately 50,000 taxicabs in the United States and their dispatching by radio would improve service and be economically feasible. The scarcity of radio channels poses a problem, which is overcome by proper geographic allocation and frequency subdivision of the communication load (*pages 232–35*).

Work Simplification. There are three ways of getting results from people: tell them, sell them, consult them. The author discusses these methods, of which the consultative approach has been the most successful, and then gives a program for work simplification (*pages 237–39*).

Patents in History. The "Statute of Monopolies" enacted by the English Parliament in 1623 and the patent laws of 1836 in America contain almost all of the provisions which are basic to our patent laws as they exist today (*pages 241–44*).

Signal and Supervision Systems. The carrier-current communication system used by the Pacific Gas and Electric Company makes use of special types of supervisory, ringing, and signaling combinations. Both power-line carriers and telephone-line carriers are used for voice, signal, alarm, and control circuits (*pages 245–49*).

Power Expansion in Italy. A brief outline is given of the concentrated expansion of Italy's electric generating capacity under the sponsorship of the Economic Cooperation Administration. Thermoelectric units are being installed to supplement present hydroelectric stations and the program also will provide power to less developed sections (*pages 262–63*).

Theory of Electric Sparking Machining. This process permits the rapid cutting of accurate and intricate shapes in materials which are ordinarily not machinable. These shapes may or may not be machined entirely through the material. This article describes the basic features of the process (*pages 257–60*).

Engineering Local Television Facilities. When pictures are seen on a television receiver screen, generally little thought is given to the complexities of the means by which local events are covered by television stations. How four Chicago television broadcasters pooled their interests on MacArthur Day and how the telephone company aided them is told in this article (*pages 252–57*).

Contact Resistance. A study has been made of the contribution that the spreading resistance makes to the total resistance of metals in contact. The spreading resistance was determined experimentally and theoretically for both round and flat specimens in which a restricting current path was introduced (*pages 264–68*).

Counting Chains for Dial Circuits. This article deals with the counting of series of dial pulses by means of relay chains. A logical review of some types of counting chains is given, leading to more systematic solutions and their use in dial pulse register circuits (*pages 270–74*).

Measurements in Cathodic Protection. A method is developed for measuring structure-to-soil potential which uses only two voltmeter readings. The method is simple, uses no delicate equipment, and is sufficiently accurate for almost all field measurements (*pages 276–78*).

News Index

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions*.

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Affiliates, Associate Members, Members, and Fellows.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Mar '51, p 35A	Winter General
Jul '51, p 23A	Southern District North Eastern District Great Lakes District Summer General
Nov '51, p 37A	Pacific General Fall General

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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Some Neglected Obligations

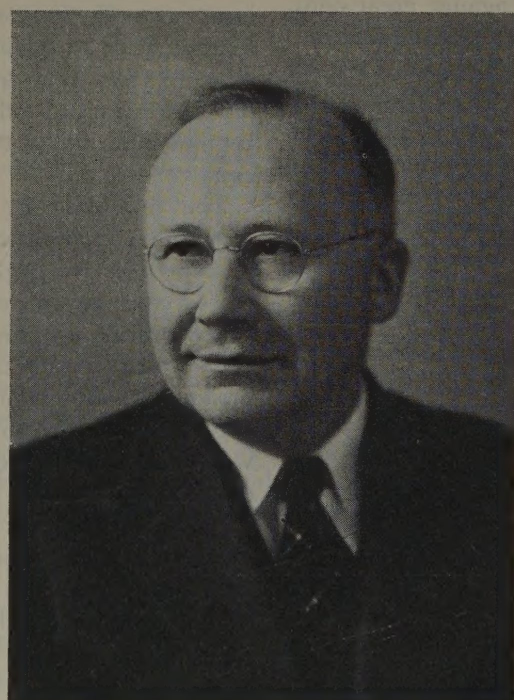
F. O. McMILLAN
PRESIDENT AIEE

In this technological age when the engineering profession is so important, it is well to remember the "Statement of Principles of Professional Conduct." It is the duty of engineers to interest themselves in the public welfare, apply their special knowledge for the benefit of mankind, uphold the honor and dignity of their profession, and avoid association with any enterprise of questionable character.

ENGINEERS AS workers in and with the natural sciences and having full cognizance of the inevitable result of disobeying the natural laws generally recognize that there are moral and spiritual laws that are quite as exacting as the physical.

PRINCIPLES OF PROFESSIONAL CONDUCT

FOR OUR GUIDANCE in dealing with our fellow men the American Institute of Electrical Engineers has adopted a "Statement of Principles of Professional Conduct." In its present form this statement was approved by the Board of Directors on August 4, 1950. The concept of such a guide for professional conduct originated in 1906 as the result of a presidential address, "Engineering Honor," by Dr. Schuyler Skaats Wheeler.



F. O. McMillan

In the period between 1906 and 1912 committees of the Institute developed a "Code of Principles of Professional Conduct" that was adopted by the Board of Directors on March 8, 1912. Continuously since that time we have had the benefit of such a guide. Prior to 1940 the American Engineering Council recognized the need for a uniform statement of ethics for the engineers of America and a special committee was originated to prepare one under the chairmanship of the late Professor Dugald C. Jackson. Following the dissolution of the American Engineering Council in 1940 the Engineers' Council for Professional Development (ECPD) assumed the sponsorship of the special committee on engineering ethics. In October 1947 the ECPD, with the approval of seven of the eight member societies, approved the "Canons of Ethics for Engineers" in their present form and recommended their adoption by the individual societies. These "Canons of Ethics" constitute a major part of the "Statement of Principles of Professional Conduct of the American Institute of Electrical Engineers."

The foreword of these Canons sets forth the broad general underlying principles and philosophy that should guide us in our professional conduct as follows:

"Honesty, justice and courtesy form a moral philosophy which, associated with mutual interest among men, constitutes the foundation of ethics. The engineer should recognize such a standard, not in passive observance, but as a set of dynamic principles guiding his conduct and way of life. It is his duty to practice his profession according to these "Canons of Ethics."

"As the keystone of professional conduct is integrity, the engineer will discharge his duties with fidelity to the public, his employer, and clients, and with fairness and impartiality to all. It is his duty to interest himself in public welfare and to be ready to apply his special knowledge for the benefit of mankind. He should uphold the honor and dignity of his profession AND ALSO AVOID ASSOCIATION with any enterprise of questionable character. In his dealings with fellow engineers he should be fair and tolerant."

RESPONSIBILITY OF ENGINEERS

AS ENGINEERS WE may become so engrossed in and preoccupied with our technical work and related problems that we lose sight of their social, economic, and political implications. The "Statement of Principles of Professional Conduct" to which we have subscribed clearly indicates that it is our duty to interest ourselves in the public welfare, be ready to apply our special knowledge for the

Full text of an address presented at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952.

F. O. McMillan is Head of the Department of Electrical Engineering, Oregon State College, Corvallis, Oreg.

benefit of mankind, uphold the honor and dignity of the engineering profession, and avoid association with any enterprise of questionable character. I sincerely hope that we will not neglect these obligations. In this technological age there are many enterprises affecting the public security, health, and general welfare that can only be clearly analyzed and evaluated by engineers. This condition places a grave responsibility upon the engineering profession. If we fail to meet these obligations the public will hold us fully accountable for our failures.

PUBLIC NOT INFORMED ABOUT ENGINEERING

Members of the Institute do not need to be reminded of the critical shortage of engineers, but as recently as December an article "Can You Predict Your Family's Future?" appeared in one of the leading home magazines. This article advised parents and through them their sons and daughters that engineering is one of the overcrowded professions. As a result of the prompt action taken by a number of engineers the editor of this magazine was informed of the true manpower situation in engineering and the February number will carry a prominent box setting people straight on the serious shortage of engineers. The Engineering Manpower Commission of the Engineers Joint Council has done a valiant job against great odds. Time, an accumulation of widely distributed misinformation, and the inertia of government agencies have all hampered their work. Much remains to be done before the general public is adequately informed about the shortage of engineers. The fact that an article can be published in a leading magazine classifying engineering as an overcrowded profession, without being challenged by its editorial staff, is clear evidence that we have not done a good job of keeping the public informed about engineering.

STUDENT MORTALITY

In engineering education our student mortality is very high. There are several factors contributing to this loss, such as lack of proper vocational guidance, hence a lack of understanding of the nature of engineering work, but one of the very important causes is a lack of adequate preparation in mathematics at the secondary-school level. We should be more actively interested in both the primary and secondary educational programs in which our engineering students are prepared for college. The educational methods employed in engineering, mathematics, physics, and other closely related sciences, both at secondary-school and college level, should be studied carefully to determine whether the present high mortality can be reduced by improved teaching and at the same time maintain a high standard of student achievement.

A considerable number of engineers are being lost to other fields after graduation. A certain percentage of such transfers are not only to be expected but are desirable; however they do represent a loss of engineering manpower after they are trained and ready for engineering work.

WORK MUST CHALLENGE ABILITY

Within the past month two former students, who have been in industry two and three years, came to discuss their future plans with me. One is employed in the West and the other in the East. Both are dissatisfied. Their salaries are satisfactory, they have been treated with courtesy by their employers, and they like their supervisors, co-workers, and associates very much. With all of these favorable conditions they are still unhappy and it is largely because their work does not challenge their ability. They can find no satisfying reward or sense of achievement in their work. One young man knows that a high-school graduate with a short period of instruction and training could do the work he is doing satisfactorily. These are not unusual, isolated cases; there are apparently numbers of engineering graduates in similar situations and their employers and supervising engineers should be doing something to improve their conditions. With some rather minor adjustments these young men could become satisfied, happy, and much more productive employees.

The practice of some, in fact many, engineering organizations of assigning young engineering graduates to the drafting board or routine work for which nonengineering personnel may be trained readily should be challenged, especially with the existing shortage of engineers. There is grave doubt in my mind whether such assignments ever should be given engineering graduates. Probably there is no more effective way of driving a spirited young man of ability out of an organization than sentencing him to two or more years at a drafting board. Usually such assignments are justified either on the ground that the men are beginning at the bottom and working up or are doing creative design.

The first case in question should cause no trouble when limited to a reasonable time, because young engineers seldom object to beginning at the bottom if, when first employed, they are clearly shown that the bottom does not also constitute a ceiling above which it is very difficult to rise. In the second case, if a man is really doing creative design work on a drafting board it is likely he could keep two or more draftsmen employed and turn out much more work when relieved of making precise scale drawings in detail.

Much criticism has been directed at the Armed Services for failure to utilize their engineering and technical personnel effectively and no doubt the criticism is justified. We should see to it that the technical activities in civil life are not guilty of the same errors or, if they are, to rectify them promptly.

In addition to the basic training, efficiency, and economics of personnel problems, some employers and supervising engineers should devote more time to stimulating interest in and enthusiasm for their work on the part of young engineers. This stimulus probably cannot be supplied in any better way than by assigning work in which these young men feel they are making a contribution worthy of their preparation and ability and in the interest of their employer.

NEED OF LEADERSHIP

There are complaints about the lack of men who are willing to assume responsibility, take the initiative, and become leaders. This complaint has justification in

experience, however; when we see how suggestions and new ideas, originating among junior engineers, are sometimes squelched, the situation becomes partially understandable. When it becomes necessary, as is the case in some instances, to slip ideas and suggestions in so camouflaged that the boss thinks they are his own in order to insure their adoption, the encouragement of initiative is at about its lowest level. Other factors that contribute to discouraging the development of leadership are the lack of adequate incentives in the form of salary differentials and other rewards to make it worth while to assume the added responsibilities and accompanying problems.

ENGINEERING SOCIETIES CHALLENGED

An editorial entitled "A Job for Engineering Societies" by F. G. Nordenholt in the October 1951 issue of *Product Engineering* urges the engineering societies to "bring to bear upon legislators and administrators the power of their prestige and influence, to the end that corruption in government shall be minimized."

Engineers and good citizens in all professions and walks of life without regard to political party affiliation have been shocked and frightened at the widespread lack of integrity and low moral standards of men in positions of public trust that permits them to place their own personal gain before the welfare and safety of the nation.

The membership of AIEE recently expressed, by ballot, its desire to continue to operate under the object as expressed in the Constitution, namely, "the advancement of the theory and practice of electrical engineering and of the allied arts and sciences and the maintenance of a high professional standing among its members." This action was a reaffirmation that they are satisfied with the objectives of the Institute; however, I feel sure that as individual citizens we wish to stand up and be counted on the side of right as we see the right.

In addition to its contributions in the technical field the AIEE is working with the other engineering societies in an effort to evolve an "engineering unity" organization through which men in all branches of engineering may work in concert on matters of common interest and concern. It is our hope and ambition that an organization soon may be effected through which engineers may contribute to the common good at local, state, and national levels.

The Challenge of the Future

CHARLES E. WILSON

We are preparing for an atomic-fission, supersonic, electronics age, and, as we turn out the weapons of 1952, we must study and plan ahead for the weapons of 1960 and '70. By so doing, the probability exists that we will not have to use those weapons.

I AM GLAD to appear again before this distinguished group of specialists in a field to which my own life has been devoted. When I spoke to you last—it seems a long time, but it was only 3 years ago—I could not have foreseen the force of events that have once more, as in World War II, taken me to Washington.

There is, however, a vast difference in the two missions. When I went to the War Production Board in 1942, it was to help prosecute a war that had already started; now I am in Washington to help prevent a third world war which might be, if permitted to occur, the end of mankind.

The nature of the conflict which now divides the world is such as to demand, on the part of the United States and all our friends in the free world, a marshaling of physical forces to so formidable a point as to strike dread in the mind and heart of any aggressor.

But material might is meaningless unless it is infused with spiritual power. The idea was expressed for all time by Jesus Christ when he asked, "What is a man profited if he shall gain the whole world and lose his own soul?"

I would have no stomach for the task assigned to me by the President of the United States if I did not believe that the world-wide contest of the free world and the Soviet Union is one that goes to the very roots of man's reasons for being on earth. It is a contest between liberty and slavery, between the principles of Christianity and the laws of the jungle.

For more than 700 years—ever since King John signed the Magna Carta at Runnymede—modern man has fought, bled, and died to establish and maintain the principles of human justice and freedom that have been taken away so ruthlessly from the hundreds of millions of human beings now under Soviet domination. You and I would not care to live if this monstrous thing were to engulf the free world as well.

WHAT EMERSON SAID

You men are specialists. You have a very valuable role to play in the task of mobilizing America's

Full text of an address presented before the General Session at the AIEE Winter General Meeting, New York, N. Y., on January 21, 1952.

Charles E. Wilson is Director of Defense Mobilization, Office of Defense Mobilization, Washington, D. C.

defenses. But you also have responsibilities of citizenship and democratic leadership. That is why, when I addressed this same meeting in February 1949, I reminded you of a famous oration made by Ralph Waldo Emerson more than a hundred years ago.

The New England philosopher was talking to the Phi Beta Kappa Society at Cambridge, Mass. That was also a group of specialists. It, too, represented aggressive and advanced forces in American life. In that oration Emerson sought to lift the nose of the American scholar out of the book in which it was buried and point it into the wind, so that it might truly sense what is going on in the world.

What you have done is good and important, Emerson said in effect, but you must be the master and not the servant of your knowledge. It is not enough to turn forever inward and become nothing but a specialist. You are a part of society as a whole; you have duties and obligations as well as privileges and distinctions.

I pointed out in 1949, and I repeat now, that there is an authentic similarity between the position of the American scholar in 1837 and the position of the engineer and physical scientist of today. The engineer and the physical scientist have developed within the past decade the most powerful and the most exquisite instruments of destruction. They must now ponder the relation of these things to society as a whole and to mankind as a whole.

The energy behind a bomb that can destroy a whole city in one minute also can be used to serve the comfort and happiness of man. Atomic fission can be a Pandora's box or it can be a cornucopia. Which it will become is a supreme test of wisdom at this hour. I call upon you, as Emerson called upon the scholars of 1837, to bring your intellects and influence to bear, as citizens and democratic leaders, in this great, this important decision.

DEFENSE MOBILIZATION PROGRAM

I firmly believe—or I would not be in Washington at all—that a mobilization not only of the physical but also of the spiritual resources of our nation can turn back the tide of Soviet imperialism and open up a vista of peace and prosperity to the whole world.

The defense mobilization program is now in mid-career. We have made a lot of progress since the treacherous dawn attack on the Republic of North Korea in June 1950, and since the President's proclamation of a national emergency in December of the same year. We have made a lot of progress, and, in some respects, we have stubbed our toes.

I could give you a lot of figures to show where we stand today, such as that we have obligated the sum of $45,000,000,000 for defense, and that deliveries now have reached a rate of $2,000,000,000 a month. But figures do not altogether tell the story. In the past year, we have set in motion the vast forces of American industry, the same forces whose productive power astonished the world during the last war.

I say the same forces, but their potential is even greater now than it was then. And when I speak of potential, I speak not only of volume but of new and fantastic weapons and superior and even more complicated equipment than we had last time.

I speak also of the perfectly obvious, but often misunderstood or unappreciated, fact that we have not been content to produce from the same base that we used last time. We are building a bigger base in terms of electric power, steel, aluminum, chemicals, oil production, and other fundamentals of modern industrialism.

The country will emerge from this intensive period of defense mobilization far better able to wage either all-out war or all-out peace. I think a lot of people will be amazed when they get the full impact of developments now well under way which are building new pillars of power under our industrial system.

What we have done so far in defense mobilization suggests the old simile of the iceberg. Only a small part of its vast bulk appears above the water. I do not have to tell this audience of the infinite preparations that must precede mass production: contract negotiations, design, specifications, and the assembly of machines and manpower.

There is nothing very spectacular or dramatic in the sight of a man bent over a drawing board, and that, so to speak, has been the posture of defense mobilization during the year 1951. But that is the vital preliminary to the roar of the machines and the torrent of end-items that eventually flows from the production lines of America.

I said that in some instances we have stubbed our toes. We did not take quick enough action to stimulate machine tool production. We have been delayed by design changes, a matter to which I should like to refer later in this address. We have been sorely handicapped by shortages of certain metals, particularly copper. In thousands of situations, such as the difficult problem of Detroit, copper has been the stumbling block.

Copper is the red gold of our time. We just have not got enough of it to satisfy the pressing demands that range from the vital matter of ammunition cases to the construction of huge electric generators. In this and other respects, such as alloying metals, the United States is partly a have-not nation. We are, of course, searching the world to remedy our own deficiencies, but meanwhile we must resort to substitutions, sacrifice, and restraint.

I have spoken of the basic expansion of our economic base. This audience is well aware that more than 7,000,000 kw were added to the nation's electric power during 1951—an increase of 10 per cent over the previous year—and the greatest expansion in a single year in the history of an industry famous for its remarkable advances.

During 1952, we plan an even greater advance, an addition, I believe, of nearly 10,000,000 kw. Over the total mobilization period, we aim at an increase of 40 per cent over the capability at the end of 1951. We have come a long way since Ben Franklin flew his kite and since Thomas Edison puttered away in his laboratory.

THE ELECTRONIC AGE

We are accustomed to the wonders of the electrical age, to the fact, for instance,that 97 per cent of the homes of America are wired for electricity. But the electrical age is now being succeeded by the electronic age whose advances, even in the short period since the last war ended, are nothing short of dazzling.

The new, fantastic weapons are all actuated electronically. When planes and guided missiles fly faster than sound, far beyond the scope of man's senses, it becomes the task of electronics to control and direct them. The cost of the electronic equipment alone in some of the new jet planes is more than the complete cost of two B-29s. Think of it! And it seems only yesterday that the B-29 was about the last word in air power.

Our awareness of electronics is emphasized by its use on the part of the enemy. In recent months, our plane losses in Korea have been due much more to action from the ground than from action in the air. It is obvious that the enemy's anti-aircraft batteries are electronically directed. Let's not kid ourselves. Such devices were not perfected in the rice paddies of North Korea or even in whatever scientific laboratories Red China possesses. They come from the Soviet Union.

The lesson is obvious. We have got to keep ourselves several long steps ahead of the potential enemy in electronics. We cannot hope to equal him in manpower, but scientific developments can give us the effect of additional divisions in the way of increased punishing power. Such developments await the skill and energy of engineers like yourselves. Possibly the job is yours more than any group of men in the United States.

I have spoken of the delays caused by design changes. I am perfectly willing to defend many of these delays on the ground that they are resulting in the improvement of the weapons we are making; and on the further ground that a veritable revolution in weapon design has occurred in the short period since World War II ended.

The last war was fought, for the most part, with piston-engine planes. In a twinkling, they have become obsolete or obsolescent for combat purposes. Industry has had to learn as it goes along how to make jet planes that will match and surpass the best the enemy has to offer.

You men know that it takes years from the time a new airplane is conceived in the minds of designers until the time it is ready for mass production. We will produce this year planes which have been in the course of development since 1946—6 long years.

Once again, the lesson is obvious. We are having difficulties with weapons we need immediately and yet we know, because of the numerous revolutionary advances in scientific knowledge, that these supermodern weapons will no doubt be obsolescent 5, 10, and 20 years from now.

SIX-POINT PLAN

We should be planning right now for the weapons of 1960 and 1970. Eight years ago, speaking before the American Ordnance Association, I outlined a plan which, if adopted, would have saved us many delays and headaches in the crisis of today; and it would save us headaches we are going to encounter in the future.

At that time, I said: "It seems intelligent and essential that there be continued in time of peace the proved framework of an organization, comparable to the War Production Board, which will be constantly available for a time of emergency and which will draw on the store of experience, good will, production technique, research technique, and planned co-operation between the armed forces on one hand and private industry on the other. This liaison should never be allowed to die."

At the same time, I submitted six suggestions:

1. Any all-inclusive program of continuing preparedness must be initiated and administered by the Federal Government, especially by the Executive Branch.
2. It must be a continuing program, not an emergency one.
3. It must be insured and supported by Congress through advice, legislation, and appropriation.
4. Industry must respond and co-operate; it must be *allowed* to do this, not hampered and frustrated.
5. In respect to the research and development phase, we should utilize existing facilities, and both service and civilian groups should be represented through advisory committees in which civilian representation balances the natural conservatism of the Army and Navy.
6. In respect to production it is most important for industry to maintain permanent liaison men on all phases of national security. There should be no domination by any particular group in this picture; there must be maximum contact and exchange.

It is utterly impossible, as we are finding once again, to mobilize suddenly for a modern war. I said so 8 years ago and I repeat it now. The bulk of the orders for the new weapons we are now building did not reach industry until March or April of last year, after appropriations became available.

Some people seem to think that tanks, planes, guided missiles, and new types of guns should flow forth automatically as soon as Congress passes an appropriation bill. They seem to think the weapons should come back by return mail, like something ordered from a mail-order house.

We are working now on the manufacture of weapons whose designs should have begun 5 years ago. Even when designs reach the point of approval, it is necessary to design and manufacture machine tools, some of them highly specialized, and that might consume even another year.

The need for future planning gains decisive emphasis in a period like the present, when technology is in a high state of creativeness. We are not preparing for the last war. We are no longer producing B-29s and B-17s. It would be the easiest thing in the world to flood the country with old models of all kinds which we could make with our hands tied behind our back.

A BUCK ROGERS ERA

We are preparing for a Buck Rogers era, the atomic-fission, supersonic, electronics age, when yesterday's brilliant ideas are already on the way to the scrapheap, and we are clamoring for the ideas of tomorrow.

That is why I plead once again, as we turn out the weapons of 1952, for the study and invention of the weapons of 1960 and 1970. To the degree that we excel in such matters, to that degree do we advance the probability that these weapons, those of '60 and '70, will not have to be used.

They will be like the shotgun behind the farmer's door

which never had to be fired because all would-be burglars knew it was ready for use at any time.

A lot of ground has been covered in this address; too much, I admit. We have come all the way from Ralph Waldo Emerson to Buck Rogers.

The thought I would like to leave with you derives from the following passage in that same 1837 speech of the New England philosopher: "If there is any period one would desire to be born in—is it not the age of Revolution; when the old and the new stand side by side, and admit of being compared; when the energies of all men are searched by fear and by hope; when the historic glories of the old can be compensated by the rich possibilities of the new era? The time, like all times, is a very good one, if we but know what to do with it."

If we but know what to do with it—that presupposes that individuals can bring influence to bear upon national and international destiny. In our free commonwealth, that is true. Unlike the peoples who live under the tyranny of the hammer and the sickle, we are free to shape the things to come.

I look upon defense mobilization not as a grinding duty but as an opportunity. It is an opportunity not only to defend the sacred principles upon which our way of life is founded; but it is also an opportunity to hold out hope to less fortunate people in the world. I have complete faith in the ultimate outcome. I have faith that the tyranny of Soviet imperialism cannot, will not, long endure; and that in the end the unquenchable spirit of liberty will prevail all over the earth.

Compensating for Quiescent Current in Multistage Magnetic Amplifiers

A. S. FITZGERALD
MEMBER AIEE

When magnetic amplifiers are connected in cascade, circuits must be provided to compensate for the effect of quiescent current in one stage on the following stage. Several circuits are discussed, with emphasis on one which combines the best features of each of the others.

WHEN A SINGLE saturating reactor is used as a magnetic amplifier the output current is not zero when there is no d-c input. In the absence of any d-c saturating excitation there is a small quiescent current I_o. The application of a d-c signal causes the output to increase from this smaller value, I_o, to a larger value, I_s. Under the conditions which give rise to maximum gain, the value of I_o is usually a substantial percentage of that of I_s, as, for example, in the order of 30 per cent.

When it is desired to use two or more such saturating reactors in a cascade multistage arrangement, it is clear that when there is no input to the first stage all of the succeeding stages likewise should be in a substantially unsaturated condition. Usual values of I_o usually exceed by a large margin the minimum response or threshold value of the next stage; indeed, more often than not I_o is enough to drive the second stage to its full output. Thus some way must be found for annulling or compensating for the effect of the quiescent current of one stage on the stage which follows it.

Several different arrangements have been devised to take care of this characteristic. For example, the circuit A[1] of Figure 1 employs duplicate reactors, one carrying the d-c input winding, and the other being a dummy, or counterpoise, having an identical magnetic core, the same number of a-c turns, but no d-c winding. These two reactors are connected to a differential transformer so that when there is no input signal the two opposing primary windings of the transformer receive currents equal in phase and magnitude and the secondary winding delivers zero output.

A somewhat similar arrangement, circuit B,[2] also employs the counterpoise principle. In this case the two a-c reactor windings are arranged as two legs of a bridge circuit, which includes the mid-tapped secondary of a transformer, from which the amplifier output circuit is energized. In like manner, when there is no d-c input the bridge is balanced and the current in the output circuit is zero.

In another method, circuit C,[2] a bucking winding is provided on the relay. This winding carries a fixed current adjusted to produce excitation equal and opposite to that which is due to I_o in the main winding. When there is no input signal the relay has zero ampere-turns. This increases to a value proportional to $(I_s - I_o)$ when a d-c signal is applied.

Essential text of paper 52-5, "Compensating for the Quiescent Current in Multistage Magnetic Amplifiers," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winte General Meeting, January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

A. S. FitzGerald is an electrical research engineer, San Francisco, Calif.

The relative advantages and disadvantages of these three systems have been discussed elsewhere[3] and need not be recapitulated here. However, it is evident that the amount of high-permeability high-cost core material required in circuit C is less than that necessary for the other two arrangements.

CIRCUIT PERFORMANCE

IT IS THE PERFORMANCE of the several types of circuit arrangement that is of interest, particularly in respect to their ability to develop gain at low input power levels.

The application of the input signal to the d-c winding of the saturating reactor causes a change in the impedance of the a-c winding. When the a-c winding is energized at an appropriate level, for which a definite optimum value exists, the signal results in a commensurate volt-ampere or power change in the a-c winding.

The problem is to make use of this power change in the output circuit in which it is desired that the power be zero when there is no signal.

Not all of this power change can be utilized in every case in the output circuit. The original change of power level in the a-c winding is subject to varying degrees of loss or attenuation in the different circuit arrangements or networks. The degree to which success can be measured in devising a compensated magnetic amplifier is the extent to which this attenuation can be minimized.

In circuit A all of the interstage power is transferred by transformation. At low power levels the question of efficiency of transformation is a cardinal one. Circuit B is better than circuit A in that the transformer used in this arrangement is energized from the source and not exclusively by interstage power.

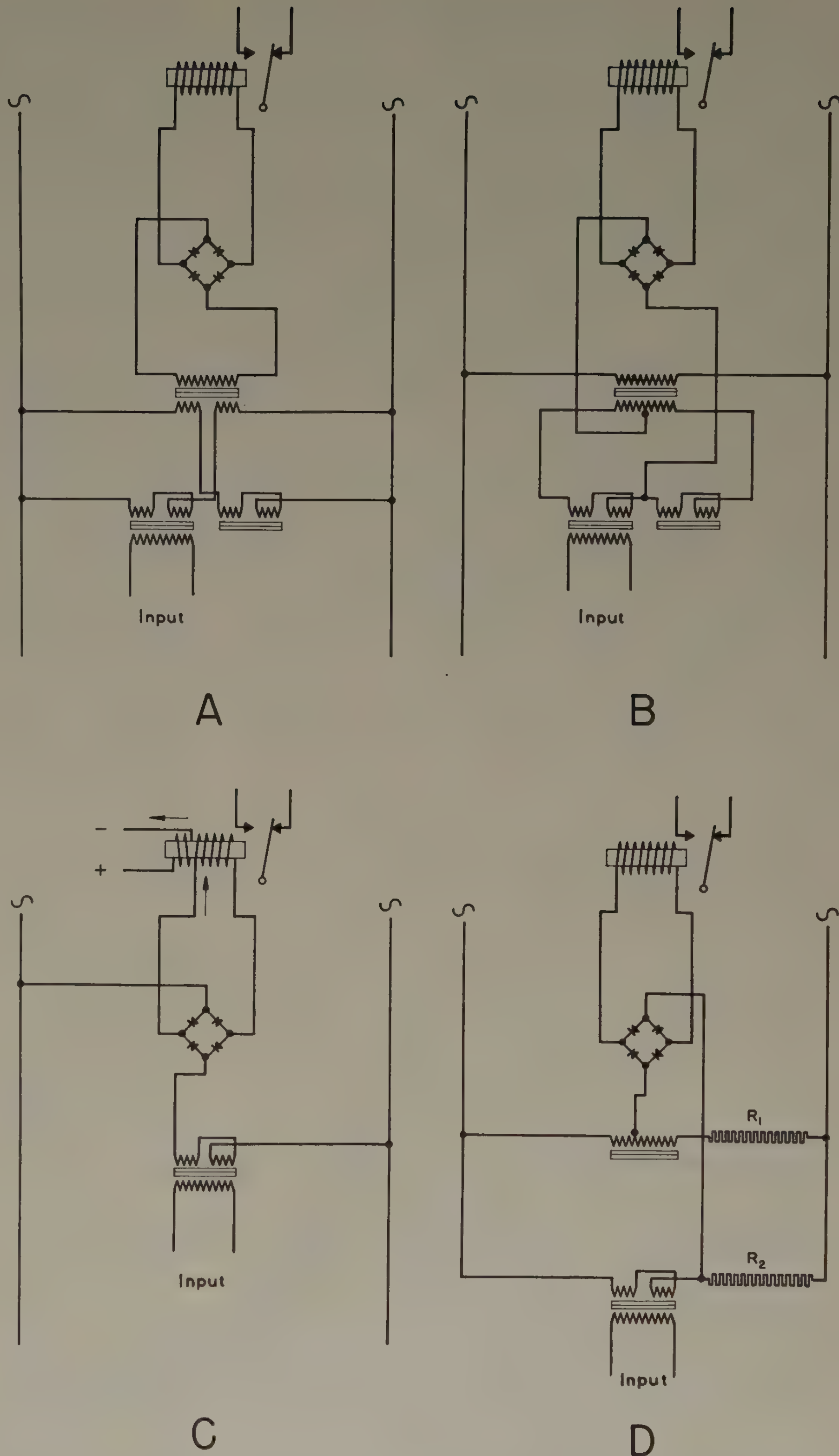


Figure 1. Four ways of compensating for quiescent current in magnetic amplifiers

In circuit C all of the power increment in the a-c winding is conveyed to the output device. That is to say, no loss in interstage transfer of power results from the presence of the compensating arrangement nor is there any attenuation introduced which would not exist in its absence. The power supplied to the relay compensating winding is not interstage power.

In Figure 2 gain curves are shown for each of the three arrangements using the same reactor. This is a 3-leg type core of *EI-3A* mumetal stacked to a square center section.[4] The curves are based on maximalized gain computations such as the author has described elsewhere.[4] The output circuit resistance is adjusted to the optimum value for each value of output plotted; and the a-c voltage is maintained at a constant value where the gain is greatest

at the value of input signal at which the peak of the gain curve occurs.

In the case of circuits A and B the output current is zero when there is no input, and the output power is the output circuit resistance multiplied by the output current squared. In the case of C the output current is increased from I_0 to I_s and the output power is the output circuit resistance multiplied by $(I_s - I_0)$.[2]

For the transformer which was used in circuit A, a mumetal core was employed in view of the low power levels involved and the transformer was designed to give maximum efficiency at the peak of the gain curve. In arrangement B the characteristics of the transformer are not a material factor in the performance of the circuit since it is merely a source of power.

All of the curves refer to 60 cycles.

The curves show the very definite superiority of circuit C, in respect to the gain developed, over the other two circuits. Systems A and B also require larger amounts of material resulting in greater weight and cost. Thus for purposes in which the output of the magnetic amplifier is to be used for furnishing ampere-turns, this method has merit. It is, for example, suitable for use in multistage magnetic amplifiers.

It is equally applicable to relays and other electromagnetic control devices. In this case it has the disadvantage that stock relays cannot be employed without dismantling them and reassembling them with special coils. It is also not applicable where an a-c output is required.

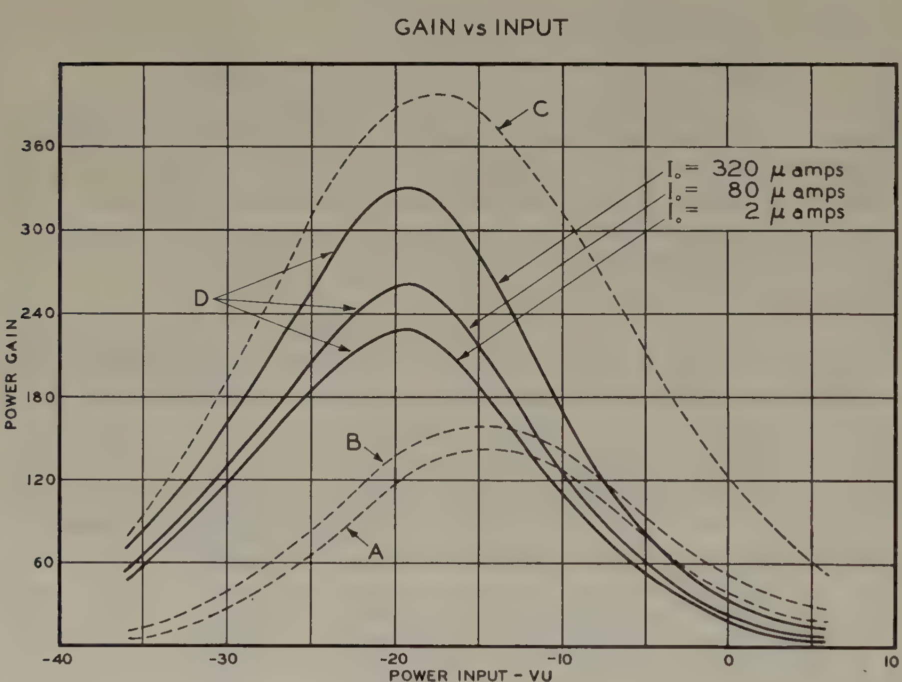


Figure 2. Comparison of gain of the four compensating circuits

A NEW CIRCUIT DESIGN

Clearly, a magnetic amplifier hookup that would combine the best features of these three methods is the thing to aim at. Such an arrangement should meet these requirements:

1. Have gain and threshold of response approaching that of circuit C.
2. Have zero output when there is no input.
3. Require a minimum of material and not more than a single core of expensive high-permeability alloy.
4. Be equally adaptable for a-c or rectified output.

The author has attempted to meet the requirements with circuit D[5] which comprises, in addition to the single saturating reactor with the usual a-c and d-c windings, a transformer and two resistance elements.

The transformer is made of regular grade transformer-type core material; no significant improvement either in gain or compensation appears to accrue from the use of nickel alloy of the same type as is used in the reactor. In the diagram the primary comprises the full number of turns and the secondary is the section to the left of the tap. There is an operational convenience in using separate windings in laboratory development, but autotransformer connections can be used in production. The number of primary and secondary turns—not merely the ratio—depend in the first place upon the characteristics of the saturating reactor, and in the second place on the power level at which it is desired to operate the amplifier. A step-down ratio in the range of from two to four is representative.

The adjustment of the circuit constants so that the output is substantially zero when there is no input is achieved when the transformer has the right ratio and draws the correct magnetizing current in relation to the reactor characteristics and the values of the two resistances so as to bring about the proper vector relations as shown in Figure 3.

In the vector diagrams the relations indicated when there is no signal are substantially authentic. In the case of the conditions which result when a signal is applied, the diagram is believed to be reasonably suggestive of the magnitudes of the several voltages involved; but it is not possible to determine or to present the phase relations of nonsinusoidal voltages with significant precision.

The circuit operates at a voltage somewhat greater than that which would be used were the saturating reactor a-c winding and the rectifier to be energized in series directly from the a-c source. The 25-volt supply commonly used for low-power control circuits is suitable. This permits the branch of the circuit which comprises the a-c winding and the resistance R_2, which has the higher value of the two resistances, to be operated under constant current conditions. It is

this feature of the design of the circuit which is an important element in securing the values of gain which this system achieves.

The path through which the power from the a-c supply reaches the output is formed by the resistor R_1 and the transformer. Increasing the value of R_1, decreasing the transformer secondary turns, or increasing the turns of the primary will tend to cut the gain.

Using the identical core, a-c and d-c windings, and rectifier with which the performance of the other three arrangements was obtained, the gain of the new circuit D is also plotted in Figure 2.

The gain figures shown in Figure 2 are very moderate ones in the light of figures usually encountered at the present time, for several reasons. In the first place, all of the tests were made at 60 cycles. Furthermore, at the time this work was done the improved core materials having characteristics superior to mumetal were not available. And in addition, no self-saturating or feedback feature is included since it is desired to present the most direct comparison possible between the inherent basic performance of the several circuits. Feedback introduces additional variable effects.

At first it may appear that the recent availability of greatly superior core materials might render the problem of compensating for the quiescent current a matter no longer of very great import. However, the performance of magnetic amplifiers is very much improved at frequencies greater than 60 cycles and the improvement in core metallurgy and increased future exploitation of magnetic amplifiers are definitely related to the use of higher frequencies. For example, the use of an a-c supply which approaches radio frequency opens up the audio field to magnetic amplifiers.

Raising the frequency also increases the values of I_o relative to the values of I_s because of increased core loss effects; and the extent to which it is possible to secure further gain by increased frequency is limited entirely by this increase in I_o due to core loss. The problem of compensating for the quiescent current in multistage amplifiers therefore is one which cannot be brushed aside.

Three gain curves are shown for the new circuit with three different adjustments of the circuit constants, which give three different values of I_0, and corresponding values of gain.

ADJUSTMENT OF THE CIRCUIT

As has been discussed elsewhere,[4] the maximum effective output of a saturating reactor occurs at an optimum value of the a-c voltage. The energization of the reactor in circuit D depends upon the value of R_2. The lower the value of R_2, the greater is the value of the current in the reactor a-c winding. In all magnetic amplifier systems which essentially involve d-c saturation of the core the element of distortion of waveshape is present in varying degrees. If desired, the value of the resistance R_2 can be made sufficiently high so that the current in the reactor does not exceed the magnitude at which serious deformation of waveform occurs. Under such conditions extremely close neutralization is possible. By careful circuit adjustment the author has obtained a value of I_o as low as 2 microamperes. This is much smaller than is likely to be attained with arrangement A or B by merely stacking the counterpoise with the same number of laminations. Careful matching would be necessary to get perfect neutralization.

However, if the circuit is set up to achieve such a low value of I_o, this results in operating the reactor at a current

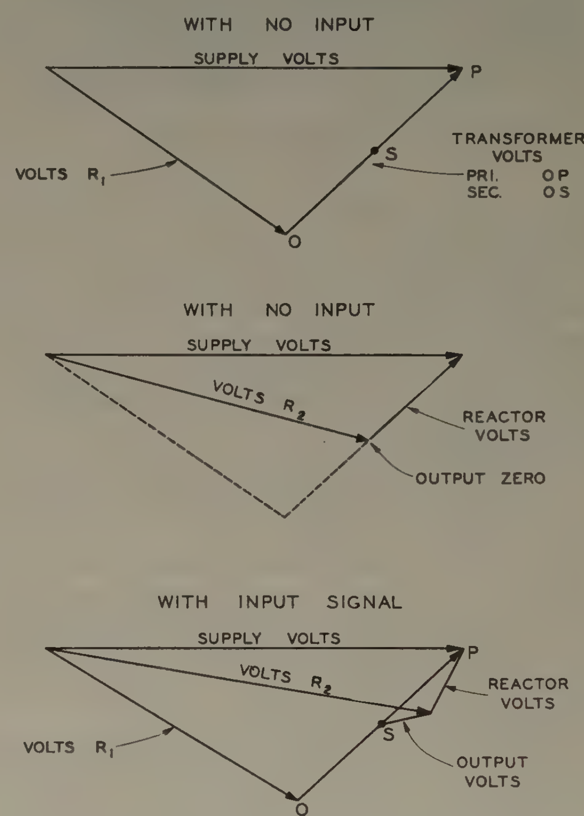


Figure 3. Vector diagram of circuit D

level somewhat less than that at which the highest gain is possible.

If the value of the resistance R_2 is made somewhat lower there will be some slight waveform distortion under the non-input condition, which will make it impossible to reach such a low value of I_o, but the gain will be improved.

The proper adjustment will depend upon the purpose for which the unit is to be used: for example, for what stage in an amplifier it is intended; at what power level it is designed to be operated; how low I_o is to be. The particular factor which determines the circuit constants is the threshold of response of the proximate stage.

The three curves are plotted for circuit adjustments which give an I_o of 2, 80, and 320 microamperes. The maximum gains are 220, 260, and 330, respectively. If the ratio of the I_o to the I_s currents, with an output circuit resistance at which the maximum gain is developed, is expressed as a percentage, for the 2-microampere setting this is less than 0.1 per cent; for the 80-microampere setting it is about 2 per cent; and for the highest gain setting it is of the order of 6 per cent.

In this connection it is perhaps of interest to note that

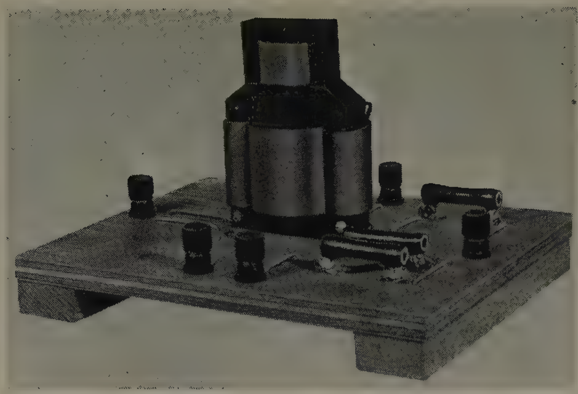


Figure 4. Complete setup of circuit D

in circuit C, at maximum gain, I_s is 13 milliamperes and I_0 is 6 milliamperes.

The I_0 current in circuit D is almost entirely a second harmonic derivative. This double-frequency current could undoubtedly be reduced materially by filtering if there were any advantage to be gained by so doing. However, the attractive feature of this arrangement would appear to be the economy of material.

The consumption of the network, for the three different adjustments shown in the curves, lies in the range from 1 to 2 volt-amperes.

The compensating transformer is extremely simple and inexpensive to construct, and need not be of substantial size relative to the reactor. Since the reactor and the transformer are matching units for any given circuit specification, it is logical to make a subassembly of these two elements, as shown in Figure 4.

The curves show that the new magnetic amplifier circuit D, while not so good as C with regard to gain and minimum response level, is superior to the other two systems.

In comparison with C it has the advantage that any output circuit or device of approximately the right resistance can be used. For example, a stock relay can be employed. Moreover, compensation is possible with an a-c output.

Compensation is independent of balance between, or aging of, rectifiers; the compensation adjustment is therefore permanent. It is also much less affected by temperature effects and by line voltage deviation than is the case with arrangement C.

With the D arrangement, in a multistage amplifier, each stage can be tested individually as a separate unit and the output read directly with a milliammeter. The I_0 value is often so small it may be neglected in computing power output; it usually cannot be seen on a meter having a scale suitable for indicating the output.

In the arrangement of C, neutralization can be accomplished only when all the stages are assembled and operating together; it is necessary to adjust the interstage currents to minimum values which are substantially removed from zero. Likewise the power output of a stage can be computed only on the basis of the difference between the I_s and I_0 current values.

A further advantage of this arrangement as compared with circuit C is apparent when the addition of feedback is considered. This can be provided readily by an additional resistor R_3 connected in series with both input and output as shown in Figure 5. This is not possible without neutralization, in the absence of which there would be feedback from the residual or I_0 current when there is no input.

If the input and output circuit resistance values are incompatible, or if it is desired to keep the input and output circuits electrically separated or insulated, a feedback winding may be used instead of a resistor, as shown in Figure 6.

Where feedback is used with a saturating reactor which is not compensated, it is necessary to provide an additional bias winding which usually calls for an extra rectifier. This is not necessary in circuit D.

A PUSH-PULL ARRANGEMENT

Figure 7 is a push-pull feedback arrangement consisting of two units similar to Figure 5. The connections to the R_3 resistors are made so that the feedback is positive on one side when it is negative on the other; and vice versa. Thus the feedback action tends to produce a greater output from one side and a reduced output on the other

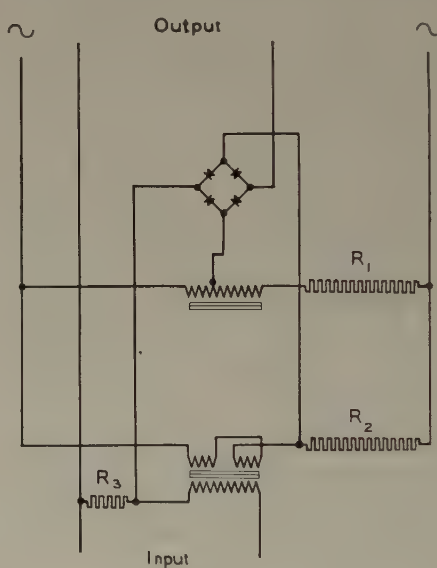


Figure 5. Feedback connections with coupling resistor

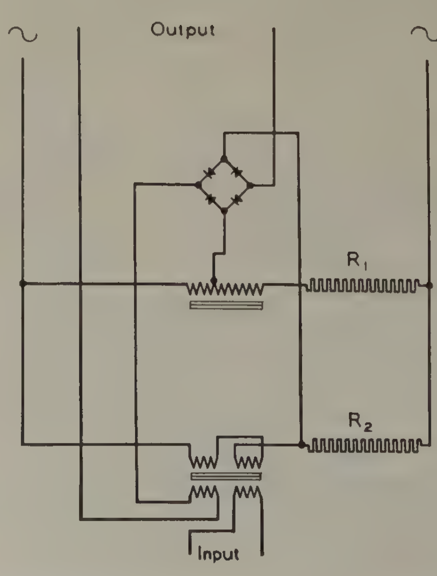


Figure 6. Feedback connections with series winding

ide, in accordance with the polarity of the input signal.

However, the selective or discriminating polarized action is not limited to this amount of increase and decrease in output only. This result would be obtained if two entirely separate feedback amplifiers with reversed feedback connections were used. In the Figure 7 arrangement the two input windings are connected in parallel, as shown in the diagram, and the voltages set up across the R_3 resistors by the output currents tend to reject signal current from the input winding which has negative feedback, and to "suck in" or increase signal current on the side which has positive feedback.

Thus, not only is there a difference in the two output currents due to the fact that each unit has opposite feedback but this difference is greatly increased because the signal current is caused to divide unequally between the two input windings.

By means of arrangements based upon Figures 5, 6, and 7, it is possible to make sensitive polarized amplifiers in which, over wide ranges of signal level, output is delivered by one side only, the current in the other side being of negligible magnitude. When the signal polarity is reversed the outputs of the two units likewise change over in polarity.

The advantage of the arrangement which gives two separated outputs, one for a positive signal and one for a negative signal, is that, when it is desired further to amplify the output of a polarized arrangement such as Figure 7 by means of additional stages, this may be done by means of simple or neutral types of amplifier such as those shown in Figure 1. These arrangements are more effective in handling substantial amounts of power than the usual polarized types of magnetic amplifier in which substantial losses usually occur in the differential or balancing circuit structure. Furthermore, most types of motors used in reversing control systems do not operate with reverse polarity input, but more usually have two different wires one or the other of which is energized for forward or reverse rotation respectively.

A modification of the circuit arrangement D may be used with some types of self-saturating magnetic amplifier circuits.

GENERAL ASPECTS OF BRIDGE CIRCUITS

A few comments as to why such a simple hookup as circuit D performs as it does may be in order. As a relic from school days, the impression is prevalent that a bridge works best when all four arms are of equal magnitude. This is true under restricted conditions such as, for example, in a Wheatstone bridge where the battery voltage is assumed to be constant. But a magnetic amplifier is not subject to such restrictions. The constant term in any of the magnetic amplifier bridge or differential circuits is not the supply voltage but the a-c energization of the saturating reactor in the absence of the input signal. This is

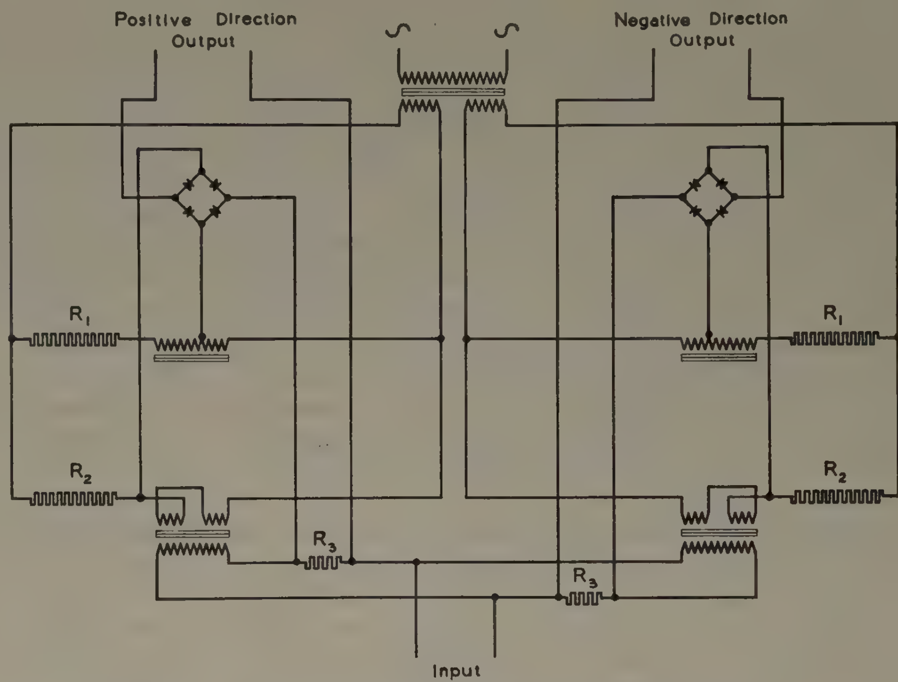


Figure 7. Push-pull polarized balance detector arrangement

a deciding factor in determining the circuit constants of the bridge. It happens that proportions for the arms of the bridge departing considerably from equality give considerably more current in the "galvanometer" circuit of the bridge than if the four arms are of nearly the same value.

When the impedance of the saturating reactor is decreased as a result of the input saturating current, the current in the a-c winding increases. This current increment is derived from the source through two channels, one of which includes the output circuit and one of which does not. If the current through the latter channel is minimized by the use of such a high resistance that a constant current condition is approached, and if the alternate path which passes through the output circuit presents a minimum of attenuating impedance, then more of the increased reactor current will flow through the output circuit and a higher gain will result.

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Dual Selective Overcurrent Trip Design Refinements

CARL THUMIM

SELECTIVE OVERCURRENT trips applied directly to large air circuit-breakers have sensitivity and accuracy approaching that of a relay, coupled with the robust construction required to withstand the shock and vibration of circuit-breaker operation. These requirements presented problems which had to be solved before satisfactory service could be obtained.

National Electrical Manufacturers Association specifications permit factory settings for the three short time-delay current pickup values as well as for the three time-delay bands in both the overload as well as in the fault current zones. For reasons of flexibility both in manufacture and in field application, the I-T-E device for any given coil rating is adjustable and will meet allowable tolerances when settings are made in the field by rule-of-thumb methods.

Since in selective tripping dependability is synonymous with permanent accuracy, the theory of design must be oriented toward these ends. Materials used for primary structures must be reliable and free from internal stresses, dimensional changes, and other physical variables. Use of close fits or small orifices should be avoided.

The power unit of the I-T-E Dual Selective Tripping Device is a clapper-type electromagnet with two armatures, independently connected to the long time-delay and the short time-delay devices. Each armature is adjusted individually for striking the circuit-breaker trip finger at its optimum point and in turn has independent pickup current value and time-delay adjustments. Each time-delay function operates during not more than the first half of the stroke of the armature which then is released to strike the trip latch with impact. To accomplish this in the short time-delay geared timer, the armature gear is released from mesh while the other gears are cam-locked in position to assure positive remeshing on reset. No pawls or ratchets are used. In the long time-delay sealed silicone-oil dashpot, the armature is released when the piston seal is by-passed by longitudinal grooves in the cylinder wall. In both cases full reset is instantaneous when the current falls to the specified reset value so that the original current pickup values must be reached before tripping action begins again.

Accuracy of short time delay is obtained by the use of a 27-to-1 gear reduction and by use of the same number of oscillations of the verge for both long- and short-time bands. Calibration results from a change in the torque rather than by the usual method of varying the number of oscillations. The natural frequency vibration of the verge is damped out by loose-rivet energy absorbers.

The long time delay is varied by bodily moving the oil dashpot cylinder up and down and thus changing the distance the armature-driven piston must move before the release point is reached. A sensitive check valve permits rapid reset with no so-called memory. During the duration of the long time delay the armature vibrates at twice the circuit frequency which results in wear of parts, loss of accuracy, and annoyance of the personnel. A tuned vibrating mass, attached to the armature, tends to "absorb" the resonant energy and thus reduce such noise.

By use of refinements which separate functions, allow independent adjustments, and minimize effects of natural or forced frequencies of vibration, it has been possible to obtain a universal direct-acting overcurrent device of robust construction with built-in accuracy which can be maintained for a long service life.

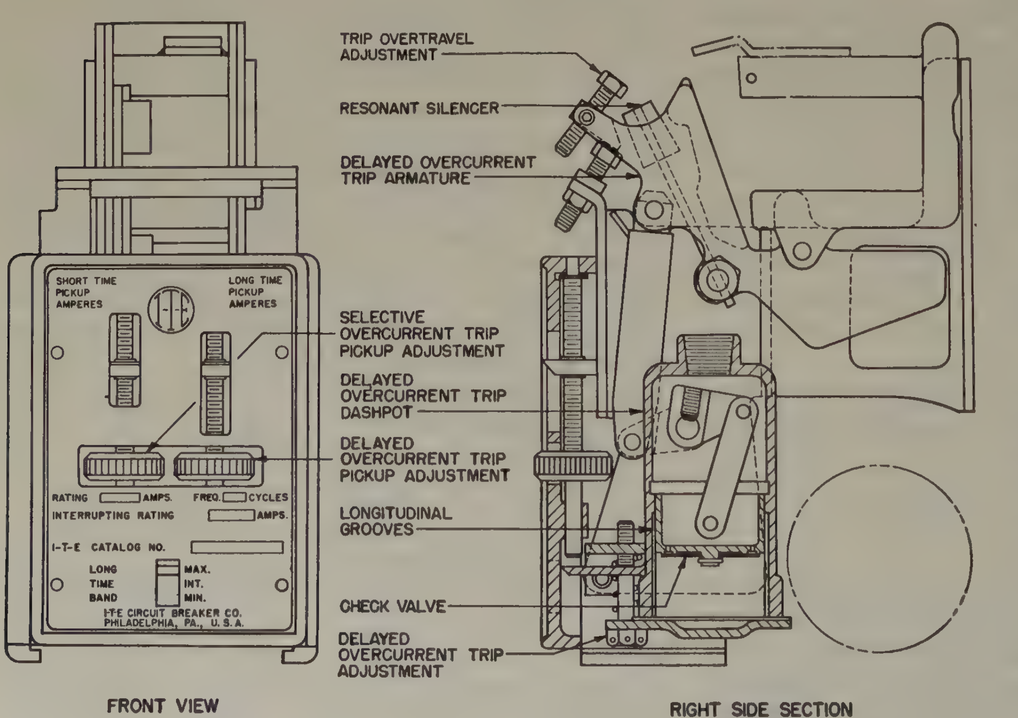

Figure 1. Direct selective overcurrent tripping device

Digest of paper 52-41, "Refinements in Dual Selective Overcurrent Trip Design," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Not scheduled for publication in AIEE *Transactions*.

Carl Thumim is with the I-T-E Circuit Breaker Company, Philadelphia, Pa.

Wanted: Growth Engineers for a Growth Industry

E. L. LINDSETH

Growth is an outstanding characteristic of the electric utility industry. If it is to continue growing at the past rate of speed it must have more electrical engineers to work in all phases of the industry, but particularly in top management positions. Both the companies and members of the engineering profession have a responsibility in solving this problem.

INDIVIDUALLY, system engineers are among the most important operating people in the electric utility industry, and this group is meeting at a time when the extent of national dependence on the industry was never more dramatically evident. Your immediate responsibilities under present emergency conditions are heavy. The industry looks to you for a solution to many technical engineering problems of today but, viewed in broad perspective, their solution is by no means your sole professional responsibility. I should like to explore that perspective very briefly.

As you well know, ours is a small-revenue, small-employment, large-investment industry. As such, it is exceptionally dependent for its growth on employee efficiency, engineering acumen, and management skill. And constant, unremittent growth is a first essential of the business. By the very nature of things, the electric utility industry is a growth industry.

Growth was never more strikingly characteristic of our industry than it is today, as the business-managed electric light and power companies press forward the 15 billion dollar expansion program which has made ours the fastest growing basic industry in the United States. But we must remember that the current international situation has not created this expansion process—it has only accelerated it. With or without wars, crises, and economic booms, the electric utility industry has grown rapidly and steadily throughout its history.

So let us look beyond the present, with which all of us are familiar, to the future, which it is our obligation as individuals and as an industry to be preparing for today. I think we can find a challenge and a lesson in such a look.

FUTURE OF THE ELECTRIC UTILITY INDUSTRY

WHAT CAN WE SEE in the future of, say, 30 years hence? We can see, first of all, that ours will be an immensely larger business with immensely larger problems. But some of us may not have thought out the magnitude of the impending change. The best way to do that is to measure the potential of the future by the accomplishments of the past. Long-range forecasting is difficult, inexact, and unnecessary for our purpose. So instead of attempting a forecast, let us simply project our industry's growth on the arbitrary assumption that it will expand in the next 30 years at the same rate at which it has grown in the past 30—roughly one-third of which were war years, one-third depression years, and one-third (if we may reactivate for the moment an almost forgotten word) normal years.

This premise of a 100-percent growth factor is arbitrary. It may be unimaginative but it certainly stimulates the imagination. For the results are astounding. On this projection basis, the electric utility industry in 1981 will sell well over 2 trillion kilowatt-hours—more than six times the estimated 1951 total of some 300 billion. Industry revenue for 1981 will reach 25 billion dollars—five times what it is today—at today's price levels. Our combined generating capacity will exceed 400,000,000 kw, and our peak load 350,000,000 kw, in 1981—both five times the present level. The industry's aggregate investment in property and plant account in 1981 will approach 150 billion dollars—almost six times today's 26.5 billion dollars. Finally, the average residential customer by the year 1981 will require 10,000 to 12,000 kilowatt-hours of electricity annually—five or six times the present home usage level.

This, remember, is not a forecast. It is simply a projection of the next 30 years at the same expansion rate at which we have grown since 1921. And we are growing today at the most rapid rate in our history.

The totals, thus arbitrarily produced, very likely will prove to be low rather than high. But the specific figures are unimportant. What is important is the fact that even if we should grow in the future no faster than we have grown in the past, our industry will get big in a hurry. At that rate we will become in just 30 years some five or six or more times as big as we are today, which will make ours, by all odds, the nation's largest industry.

THE NEED FOR TOP MANAGEMENT

WHERE DO ELECTRICAL ENGINEERS fit into this picture? The answer is obvious. If our industry is to solve successfully this fivefold multiplication of operations, responsibilities, and problems, it must have more and more electrical engineers for research, design, construction, and operations, and, above all, for top management positions.

Skilled executive manpower is, in fact, the industry's greatest single need for the future. Yet even at today's

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Essentially full text of an address presented at the System Engineering Session during the AIEE Fall General Meeting, Cleveland, Ohio, October 22–26, 1951.

E. L. Lindseth is President, The Cleveland Electric Illuminating Company, Cleveland, Ohio.

size level, we are already deficient in that very commodity.

American industry's over-all shortage of engineers is critical. But it is secondary, I believe, to the shortage of qualified top executives. This shortage seriously threatens America's productive capacity, both immediate and long-term, and it finds expression in the electric utility industry even more than in others. In our case, the implications are especially serious, for if we cannot find enough capable executives to run a 26.5 billion dollar industry, how are we going to fill the tremendously increased management needs of the 150 billion dollar industry we will become?

That, I think, is importantly up to electrical engineers, for it is to you, certainly, that we must turn for a great many executive additions and replacements. So let me ask each of you this: will you personally be ready for the call to higher responsibilities when it comes? Are you preparing your understudies to move up to top executive responsibilities? There is reason to believe that for many of you an honest answer, as of today, would have to be no!

All of you have, or are well on the way to acquiring, the technical competence required for top management of an electric utility. It is because you possess this invaluable fund of background knowledge and ability that the industry must give you first priority for management. But this alone is not enough.

REASONS FOR SHORTAGE OF EXECUTIVE MANPOWER

MANAGEMENT COMPETENCE requires a peculiar combination of technical ability and management skill. These two requisites are separate and distinct. Each must be acquired studiously and developed aggressively. They are complementary but they are not synonymous, and not entirely harmonious.

Perhaps the major deterrent to the acquisition of an adequate pool of executive talent in our industry as well as others has been the fact that, as Lawrence Appley, American Management Association, has pointed out, technical engineering training not only does not assure management competence, but seems actually to militate against the development of management skill. For, to quote Marvin Bower, McKinsey and Company, New York, N. Y., "What may be good training for the technical specialist may often be poor education for the chief executive."

This paradox is not understood easily. But in his engineering capacity the engineer too often requires meticulous attention to detail, exclusive concentration on the problem at hand, and the specialized approach. In a top management position, on the other hand, that same engineer needs entirely different qualities, among them the ability to relate individual problems to a broad-gauge over-all company effort and, beyond that, to broad considerations of social, economic, and political policy.

How many of you are developing in yourselves and in those you are responsible for training the competence to meet those management responsibilities, to exercise that sort of broad judgment in these wide areas of social responsibility? In this particular gathering, the percentage is doubtless high, but for electrical engineers as a group, and among engineers generally, it is not high enough.

That fact is pointed up clearly by the postwar survey which found that only 31.9 per cent of America's electrical engineers are employed in administrative and management positions. That is fewer than one in every three and the study included all levels of management.

Perhaps this is not surprising in view of the differing requirements of engineering specialization and broad management competence. But it is certainly undesirable at a time when qualified executives with technical background are needed so urgently by every American industry.

RESPONSIBILITIES OF ENGINEERS AND INDUSTRY

IT'S UP TO BOTH engineers and industry to do something about this situation and to do it now. It is up to companies throughout our own industry to follow the lead of those few which already have instituted broad-scale executive development programs designed to give the top management of tomorrow a fundamental education in the social responsibilities, as well as the professional requirements, of business leadership. And it is up to you people to participate actively in those programs, to make every effort to prepare yourselves and those engineers, for whose growth and development you are responsible, for the ever greater and more exacting responsibilities of utility management.

The first need of our industry even today is not engineers but engineering-trained managers. In fact, the filling of the latter need for engineering-trained executives will do much to solve the need for engineers themselves. In the next 30 years both of these needs will be multiplied many times over. But above all else, we must have engineers capable of matching in personal development the tremendous rate of growth in prospect for the electric utility industry and we must get them from your ranks.

The technical engineering requirements of the moment are great. But for the future you face a far greater challenge: the responsibility of becoming truly growth engineers in this great growth industry.

Electronic Regulator for Steam Turbine

Electronics makes possible a static regulator with faster response than obtained with the conventional hydraulic governor. The electronic governor, announced by the Westinghouse Electric Corporation, can give a steady-state regulation of 0.5 per cent. The amount of overshoot when recovering from a transient condition has been reduced. Recovery time to a steady-state condition with sudden removal or addition of full load is limited to less than 2-per-cent addition to the speed regulation. The basic part of the electronic unit is a frequency network that detects the variation from the basic frequency and provides a signal voltage proportional to this deviation. This signal voltage is stabilized and amplified and controls the solenoid cup valve, the important connecting link between the hydraulic system and the electronic system. The solenoid cup valve then controls the hydraulically operated steam-inlet valves.

Selection of a Carrier Relaying System

R. C. CHEEK
MEMBER AIEE

J. L. BLACKBURN
MEMBER AIEE

TWO BASIC TYPES OF carrier relaying systems are available today. These are the power-directional-comparison system and the phase-comparison system. With two distinct basic systems to select from, the relay engineer is confronted with the necessity of making a choice between them for any application where use of a carrier-pilot system is indicated. The purpose of this article is to discuss the relative advantages and limitations of each system and to point out certain considerations that have a bearing on the choice of a system for a specific application.

The relative advantages and disadvantages of each system, as exemplified by the type *HZ-HZM* system (directional-comparison) and the type *HKB* system (phase-comparison), are summarized in Table I. The degree of complexity of the two systems is about equal if backup relaying is included. However, the absence of inherent backup protection in the phase-comparison system is an advantage in applications where the carrier system is used to supplement existing slower-speed relays.

A major advantage of the phase-comparison system is that no potential transformers or potential devices are required for its operation. Also, because the phase-comparison system operates from line current alone, it is immune to out-of-step conditions. Other advantages of the phase-comparison system are its immunity to false operation as a result of zero-sequence induction from parallel lines, unequal closure of circuit-breaker poles, and loss of potential due to blown potential transformer fuses or other causes.

The application of the phase-comparison system normally is limited to those lines on which an adequate margin between load and fault currents exists at all times. The minimum internal 3-phase fault current through either terminal of a 2-terminal line should be about 165 per cent of the maximum load current. If load and fault currents on the line to be protected do not meet these requirements, several alternative methods of operation of the phase-comparison system can be employed. In general, however, even where the first choice is the phase-comparison system, but the required fault-to-load current margin cannot be obtained, the directional-comparison system usually is applied.

The problem of discrimination between load and fault is practically eliminated in the directional-comparison system. Relays used in this system can detect fault currents of smaller magnitude than load currents and for 2-terminal lines are practically independent of variations in fault current. Thus, the directional-comparison system is applicable to almost all lines, whereas in many cases the phase-comparison system cannot be used. Hence, the directional-comparison system is somewhat more versatile than the phase-comparison system.

The versatility of the directional-comparison system is further demonstrated in the protection of multiterminal lines. There are many variations of these, but except in unusual cases high-speed protection is possible only with pilot-type relaying if it is possible at all. The phase-comparison system can be applied to 3-terminal lines, but the minimum 3-phase current on internal fault must be about 333 per cent of the maximum load current through any terminal. The application of this system to a 3-terminal line with a limited source of fault power at one terminal usually is not satisfactory. If the back-feed at the third terminal is negligible, however, phase-comparison relays can be applied provided that: 1. the maximum load current through either of the other terminals to the third is less than 25 per cent of the 3-phase fault current setting of the carrier-start relay elements; and 2. the maximum fault-current contribution through either main terminal to faults beyond the third terminal is less than 50 per cent of this same setting. These conditions sometimes are met when the third terminal is a tap supplying a relatively light load through a transformer.

Table I. Summary of Advantages and Disadvantages of the Two Basic Carrier Relaying Systems

Power-Directional Comparison, Type HZ-HZM	Current-Phase Comparison, Type HKB
Contains more mechanical elements	Contains more electronic elements
Potential source required	No potential source required
Contains phase backup elements	Backup protection entirely separate, hence can be used with existing relays as backup
May trip on swings or out-of-step unless special elements are added	Will not trip on swings or out-of-step conditions
More applicable to multiterminal and tapped lines	Restricted application to multiterminal or tapped lines
Can operate on fault currents less than load currents	Margin between maximum load current and minimum fault current recommended
Generally more flexible to system changes and addition of tapped loads	

With the directional-comparison system, the magnitude of the tap load is not so critical, but it is often necessary to apply offset-type distance relays to multiterminal lines, with the third zone offset in the backward direction. The directional-type system is more flexible in such applications than the phase-comparison type and usually can be applied to provide high-speed protection for multiterminal lines, even though compromises are sometimes necessary for successful operation.

Digest of paper **52-2**, "Considerations in Selecting a Carrier Relaying System," recommended by the AIEE Committee on Relays and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

R. C. Cheek is with the Westinghouse Electric Corporation, Baltimore, Md., and **J. L. Blackburn** is with the Westinghouse Electric Corporation, Newark, N. J.

Charles F. Wagner—Edison Medalist for 1951

The Edison Medal has been awarded this year to Charles F. Wagner, Consulting Engineer, Westinghouse Electric Corporation, for "distinguished contributions in the field of power system engineering." The Medal, awarded annually by the Edison Medal Committee of the AIEE, is for meritorious achievement in electrical science or electrical engineering or the electrical arts.

The Edison Medal

J. F. CALVERT
FELLOW AIEE

CONCERNING just ordinary people a young man once remarked,

> "*Each man's life is very like his brother's*
> *And phase for phase, the like of countless others.*"

It is in contrast with this broad and rather uniform background that we see exceptional accomplishment so clearly and are refreshed by the discovery and appreciation of masterful achievement.

In 1904 a group of friends formed the Edison Medal Association, as they said, ". . . for the purpose of . . . recounting . . . the achievements of a quarter of a century in the art of electric lighting, with which the name of Thomas

The Edison Medal

Alva Edison is imperishably identified." These men established an award to "serve as an . . . incentive to scientists, engineers and artisans . . ." The medal which signalizes this recognition bears on one side a likeness of Thomas Edison and on the other, in symbolic form, a representation of the genius of electricity crowned by fame.

The Edison Medal Association gave to the American Institute of Electrical Engineers the responsibility for making these awards. The Institute carries out its trust through the actions of 24 men, known collectively as the Edison Medal Committee. Each year from among the residents of the United States and of Canada the committee seeks anew, and studies the accomplishments of men in the fields of electricity.

From years past there come to mind the names and achievements of the great recipients. The first was Elihu Thomson in 1909. I shall name others in chronological order, but quite at random, since it would be brash, indeed, to suggest any order of preference within this list. There was George Westinghouse, in 1911; Alexander Graham Bell, in 1914; Benjamin Garver Lamme; Robert A. Millikan; Frank B. Jewett; Willis R. Whitney; Edwin H. Armstrong, in 1942; Vannevar Bush; Philip Sporn, in 1945; and Otto B. Blackwell, in 1950. These are among the Institute's selection of men eminent for discovery, invention, research, design, education, engineering planning, and administration.

We are here to honor the 41st Edison Medalist. In this regard, I am reminded that Justice Oliver Wendell Holmes once said,

"The mark of the master is that facts which before lay scattered in an inorganic mass, when he shoots through them the magnetic current of his thought, leap into organic order, live and bear fruit."

And I believe that it is with thoughts in mind not unlike these that we gather today to honor Charles F. Wagner. In doing so we commemorate Edison by adding one new name to the list of Medalists, those illustrious heirs to Edison's creative genius.

Full texts of the presentation and acceptance addresses given at the Edison Medal ceremonies held during the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952.

J. F. Calvert, Chairman of the Edison Medal Committee, is Chairman of the Electrical Engineering Department, Northwestern University, Evanston, Ill.

The Edison Medalist

A. C. MONTEITH
FELLOW AIEE

THE PIONEERS OF the electrical industry were more foresighted than I believe they realized in establishing medals such as the Edison to be presented today. The occasion makes us pause in our fast-moving pace to inventory the most important factor in our industrial progress—men. The occasion causes us to consider

A. C. Monteith is Vice-President, Westinghouse Electric Corporation, East Pittsburgh, Pa.

and recognize those who have contributed the ideas and leadership that have made possible this great rate of progress. Today is a very pleasant milestone in the life of the man we are honoring. It is equally pleasant for me to have the honor of briefly sketching the accomplishments of our 1951 Edison Medalist, Dr. Charles Frederick Wagner: pleasant for me because I have watched at close range and admired the work of this man over a 30-year period. During that time he has contributed much.

His engineering career has been entirely with the Westinghouse Electric Corporation, which he joined in 1918 after receiving his bachelor's degree in electrical engineering from Carnegie Institute of Technology and after completing graduate work in physics at the University of Chicago.

PROFESSIONAL ACTIVITIES

His first 5 years with Westinghouse were spent in the Research Laboratories. There he carried on numerous investigations in varied fields that laid the groundwork for his transfer to the staff of the late Dr. C. L. Fortescue. His contributions have been continuous. It was at this time that I had first contact with him. He already had established himself as a clear thinker and a good teacher, as I can personally attest, as I have had many opportunities to take advantage of his patient and considerate counsel.

Charles F. Wagner

During the 1920's the use of electricity was expanding rapidly. Many problems incident to the necessary transmission of power were occupying the attention of the electrical industry. The public already had been taught to accept without question a high order of reliability of electric power. Continuous service was taken for granted. Outages of any kind represented a serious economic loss to the utilities and justified a thorough investigation of the whole problem.

The problem divided logically into two parts: the cause of the disturbance, which was almost invariably lightning; and the effect, which frequently was loss of synchronism between the two ends of the line (loss of their system stability). Both parts gave birth to numerous investigations all over the world in the next 15 years. Wagner contributed materially to the mass of knowledge accumulated in both fields.

In the early years, Wagner concentrated more on system stability than on lightning phenomena. As a first step he thoroughly investigated the theory and behavior of synchronous generators. He showed how the design of damper windings on synchronous machines influenced the stability of the generators and the system on which they operate. He analyzed the behavior of synchronous machines under unbalanced conditions involving negative-sequence quantities. He predicted and provided the method of analysis of high voltages created when a synchronous machine is connected to capacitive loads under unsymmetrical short-circuit conditions. He developed a considerable part of the theory and methods of analysis of the performance of power systems under transient fault conditions. The papers published jointly with the late R. D. Evans and by Wagner alone form an important part of the background for our present understanding of power-transmission stability.

Having contributed much to the effects and correction of power-transmission disturbances, Wagner turned his attention to the primary cause of trouble. His first step was to design a number of instruments for recording the currents in natural lightning strokes to towers and masts. One of these was the fulchronograph, which records the complete waveshape of long-tailed natural lightning surges. Installations of the fulchronograph have been made on several power systems, tall chimneys, and fire towers. The records obtained have added materially to our knowledge of the true nature of lightning and protection against it.

More recently, we find Wagner doing good work in the study of corona and radio-influence factors as they affect the design of extra-high-voltage transmission lines. He has contributed to several outstanding papers on the subject.

The instincts of the teacher crop out continually. He developed and built a mechanical model to illustrate the behavior of travelling waves on transmission systems. This model has been demonstrated before 75 AIEE Sections and similar groups. His versatility is illustrated by his patents, of which he holds 32, and by his writings.

AUTHORSHIP

Wagner is a Fellow of the AIEE, a member of Tau Beta Pi and Sigma Xi honorary fraternities, and a recipient of the Westinghouse Order of Merit; in 1944 was awarded the honorary degree of Doctor of Engineering by Illinois Institute of Technology. He has been a prolific writer, having contributed some 70 papers and articles to technical literature, over 20 of which have been for AIEE.

Two of his AIEE papers on system stability won for him and his collaborator, R. D. Evans, the George Montefiore Prize for the "best original work contributing to scientific advancement in the technical application of electricity." For another paper on generator characteristics he was awarded, in 1938, the AIEE Best Paper Prize in Engineering Practice. In 1942, he, with his coauthors G. D. McCann and C. M. Lear, received the AIEE Best Paper Prize in Theory and Research; and he has, with coauthors Gross, Naef, and Tremaine, just won the first prize in the Power Division of AIEE for a paper on corona investigations.

His technical writing has been concerned with almost all fields of central-station work from symmetrical components and general transient work to system stability, rectifiers, converters, system short-circuit studies, regulators, generators, condensers and induction motors, lightning, and the protection of transmission lines. He was also one of the coeditors of the "Electrical Transmission and Distribution Reference Book," the author of its chapter on Machine Characteristics, and the coauthor of the Lightning and Travelling Wave chapters.

Wagner also attained fame by his work on symmetrical components. While the fundamentals of symmetrical components were first enunciated on their general terms in the 1918 paper by Dr. C. L. Fortescue, little application of this powerful tool was made for some time. In a notable series of articles that appeared in the *Electric Journal* between 1928 and 1931, Wagner and Evans laid the groundwork for the present method of calculation, including a discussion of the determination of the constants of various elements comprising systems. This series of articles was later expanded, in 1933, into a book entitled "Symmetrical Components," that remains today the text used in practically all the colleges that teach this subject.

Lest I leave the impression that our Medalist is only a slave to work, let me point out that there are many other sides to his fruitful life. He is an enthusiastic photographer, having gone through all the phases of this hobby to 3-dimensional color projections. His pictures are not random pictures of things, but are real, artistic accomplishments. He is a skilled bridge player, and enjoys good music.

Because I have known Wagner and his work for so many years, it is indeed a pleasure to brief his achievements and pronounce my personal esteem for him both as an engineer and a man, and to greet him as the Edison Medalist for 1951.

Edison Medalists

Elihu Thomson 1909	E. W. Rice, Jr. 1931
Frank J. Sprague 1910	Bancroft Gherardi 1932
George Westinghouse 1911	Arthur E. Kennelly 1933
William Stanley 1912	Willis R. Whitney 1934
Charles F. Brush 1913	Lewis B. Stillwell 1935
Alexander Graham Bell 1914	Alexander Dow 1936
Nikola Tesla 1916	Gano Dunn 1937
John J. Carty 1917	Dugald C. Jackson 1938
Benjamin G. Lamme 1918	Philip Torchio 1939
W. L. R. Emmet 1919	George Ashley Campbell . . . 1940
Michael I. Pupin 1920	John B. Whitehead 1941
Cummings C. Chesney 1921	Edwin Howard Armstrong . . 1942
Robert A. Millikan 1922	Vannevar Bush 1943
John W. Lieb 1923	E. F. W. Alexanderson 1944
John W. Howell 1924	Philip Sporn 1945
Harris J. Ryan 1925	Lee de Forest 1946
William D. Coolidge 1927	Joseph Slepian 1947
Frank B. Jewett 1928	Morris E. Leeds 1948
Charles F. Scott 1929	Karl B. McEachron 1949
Frank Conrad 1930	Otto B. Blackwell 1950
Charles F. Wagner 1951	

Thirty Years of Power Transmission

CHARLES F. WAGNER
FELLOW AIEE

I APPRECIATE THE great honor that this Medal conveys, but am not unmindful that such accomplishments that I have made are due in no small measure to the character of the engineering minds to which I have been exposed in my daily work and in my Institute activities. I have been particularly fortunate in my associations at Westinghouse. My first position was directly under Dr. Chubb and my first assignment was for Dr. Slepian. Later I worked very closely with Dr. Fortescue and much of my writing was in collaboration with Mr. R. D. Evans. This is merely to mention a number of the outstanding minds.

On an occasion of this nature it is customary that the recipient comment briefly on a subject of his own choosing. In my own case my thoughts naturally turn to elect transmission and associated subjects. As one gets olde. one has a tendency to turn philosophical, and as I ponder the subject of transmission, my thoughts explore the factors that made possible the enormous expansion in power transmission and interconnection during the past 30 years.

In my opinion, we are now at a milestone in transmission. We are about to see the inauguration of the next higher transmission voltage in this country on the system of the American Gas and Electric Company. Other utilities are interested in the possibilities of higher voltage transmission. In Europe interest centers around the introduction of a still higher voltage. This appears, therefore, to be an appropriate time to stop and question what were the technical developments responsible for this great expansion in transmission of electric power.

LIGHTNING PROOFING OF LINES

IT IS DIFFICULT TO outline the basic factors as there is a great interrelation between various features of this problem. I am inclined to think, however, that the most important single factor was the lightning proofing of lines. The development of these ideas is a good example of the unforeseen end product of an investigation. The industry undertook a comprehensive study of the properties of lightning and the voltages it produced in the form of surges on transmission lines. While analyzing the results of

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AIEE President McMillan is presenting the Edison Medal and scroll to Dr. Charles F. Wagner, Westinghouse Electric Corporation consulting engineer, for "distinguished contributions in the field of power system engineering." The presentation was made at the General Session of the Winter General Meeting on January 21

field tests, it was observed that only very small surge voltages appeared on transmission lines as the result of a stroke nearby, whereas the prevailing theories indicated that large voltages should have appeared. These experiments resulted in a drastic modification of the theory pertaining to transmission-line protection against lightning, and therefrom followed the modern theory regarding ground wires and their location and the realization of the importance of low tower footing resistances. Attention was diverted from the old "induced" stroke theory to the modern so-called "direct stroke" theory.

FUNDAMENTALS OF SYSTEM STABILITY

THE SECOND IMPORTANT factor in the transmission problem was the development of the fundamentals of system stability. These concepts might be divided into two general categories: first, those pertaining to the relative motion of the rotors of synchronous machines; and second, the representation of unbalanced fault conditions, through the application of symmetrical components, by an equivalent balanced impedance at the point of fault. The importance of stability was first recognized in 1924 when it was proposed to transmit power from Carillon Falls to Boston. While this project never materialized, the preliminary studies led to an intensive analysis of the basic factors which was followed by the presentation of numerous papers before the Institute between 1925 and 1928.

Machine Analysis. Concurrent with and inextricably associated with the stability problem was the development about this same time of the modern theories of machine analysis. The 2-reaction method of resolution of the reactions within a machine was greatly expanded and refined. The concepts of transient and subtransient reactions in the direct and quadrature axes were introduced. The effect of the demagnetizing short-circuit currents and the annulling effects of quick response were analyzed and made more understandable.

A-C Calculating Boards. The complicated calculations involved in the stability problem quickly led to the development and construction of a-c calculating boards. Unless a problem can be simplified to the equivalent of a 3-machine problem, it is almost hopeless to analyze the system by means of the conventional longhand methods. With the a-c calculating board, the actual system is set up in miniature and the acceleration or deceleration of the rotors determined with little labor. The a-c board is also of value in system planning by predetermining voltage regulation, the flow of real and reactive power and losses. To a lesser extent, the a-c board is also useful in the application of relays and circuit breakers. When the first two boards were constructed, there was some concern as to whether the industry could keep them fully occupied all of the time. The extent of acceptance of a-c boards can be measured by the fact that today there are in the United States alone about 30 boards in practically continuous use all of the time.

The stability studies led to the early appreciation of the importance of rapid clearing of faults and prompted the development of high-speed relays and circuit breakers. This was followed by the introduction and widespread acceptance of reclosing circuit breakers.

A SUPERHIGH-VOLTAGE NETWORK

IN CLOSING, I wish to speculate on what the future holds. It appears that we are at the threshold of another great expansion in high-voltage transmission. Individual systems are finding it essential for their own needs to tie their systems together more closely. Thus the nation will be spotted with segments of high-voltage systems of 220 kv or higher.

With such component links available, will not the industry, sooner in some places, later in others, find it desirable to extend these links to adjoining systems? With this as a possibility, and I wish to emphasize this point, the industry might well ponder the desirability of agreeing upon a common voltage so that the ties might be metallic without the limitations, such as thermal capability or impedance, that intervening transformers might impose were the voltages different. Such a step, while having only moderate immediate benefit, would be bound to show up to greater and greater advantage as time goes on.

Let me thank you, President McMillan, and the Institute for finding me worthy of this great honor.

An Apparatus for the Study of the Human Operator

C. E. WARREN
MEMBER AIEE

P. M. FITTS

J. R. CLARK
ASSOCIATE MEMBER AIEE

THE QUANTITATIVE UNDERSTANDING of the behavior of a human being functioning as an element of a closed-loop control system has become a matter of considerable importance in recent years. In addition to the purely military problems of high-speed flight, fire control, and similar tasks, there are many situations where a specific knowledge of human characteristics would make possible improvements in design and performance of the over-all system. The rapid development of the theory and practice of feedback control systems has given new impetus and interest to the study of the nature of human behavior in analogous situations.

The electronic pursuit apparatus described in this article contains several features of interest. For example, it provides automatically several scores of the human's performance, such as mean error, mean square error, and time-on-target scores for three different error bandwidths. Automatic scoring is a desirable feature because of the large quantities of data which must be collected for statistical analysis.

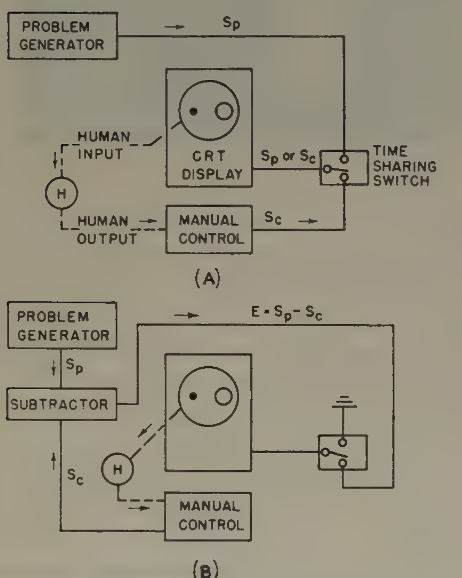

Figure 1. Block diagram showing circuit connections for following and compensatory types of pursuit problems

The two basic types of pursuit problems provided by the apparatus are shown in Figure 1. Figure 1*A* illustrates a following-pursuit situation. In this case the target (dot) is caused to move horizontally with a prescribed time variation in proportion to the signal S_p generated by the problem generator. The human manipulates the manual control producing a signal S_c which causes a proportional motion of the cursor (circle). The basic task of the operator is to keep the circle superimposed on the dot. Figure 1*B* illustrates the second basic type of problem, which is designated compensatory pursuit. In this case the error signal E is fed to the time-sharing switch which now is connected so that the dot is stationary at the center of the display tube and the error signal causes a proportional motion of the circle. Figure 2 is a block diagram of the pursuit apparatus indicating the major electrical and mechanical interconnections in the apparatus. The output of the manual control may be set to give a proportional, a rate, or a rate plus proportional control signal. The manual control and display scale factors permit independent adjustment of the amount of control motion per unit signal generated and the amount of display deflection per unit of signal. One of the major objectives of these studies is the determination of the range of problem variables to which the human can learn to adapt himself and perform at a maximum level of skill.

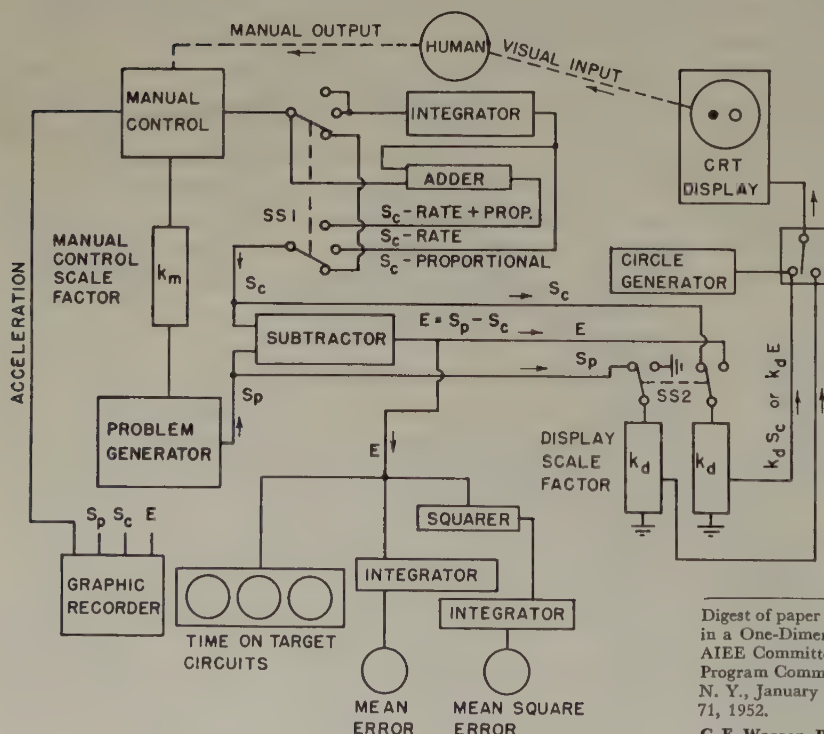

Figure 2. Block diagram of electronic pursuit apparatus

Digest of paper 52-8, "An Electronic Apparatus for the Study of the Human Operator in a One-Dimensional, Closed-Loop, Continuous Pursuit Task," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

C. E. Warren, P. M. Fitts, and **J. R. Clark** are all with Ohio State University, Columbus, Ohio. This work was supported in part by the United States Air Force and was monitored by the Air Training Command, Human Resources Research Center.

Regulation of a 115-Megawatt Turbogenerator

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A 115-MEGAWATT 95-per-cent power-factor generator, having a short-circuit ratio of 0.66, has lost synchronism occasionally during faults in the 20 years it has been in service at the Waukegan Station of the Public Service Company of Northern Illinois. During faults the the generator terminal voltage became so low that the generator lost a large share of its load and the rotor accelerated, thus allowing the generator to swing out of synchronism. It was decided to investigate possibilities of using automatic voltage regulation to maintain generator voltage.

Preliminary studies showed that the rheostatic-vibrating type of voltage control required twice the time taken by the static-network rotating-amplifier type to restore terminal voltage, and also that normal voltage restoration time could be reduced further by replacing the 250-volt (300-ceiling-volt) exciter with a 350-volt (500-ceiling-volt) exciter. Using the latter equipment, further studies were made of transient load changes by simulating conditions under which the unit became unstable in 1947 when manually controlled. The initial load of 60 megawatts was changed suddenly by increasing the mechanical power input to the generator to 100 megawatts. The studies showed that without automatic voltage control the generator lost synchronism on the second swing, or in about 3 seconds. With automatic voltage control the generator remained stable; that is, the automatic voltage control would operate to increase the exciter voltage and prevent the decay in magnetic field strength normally caused by increased generator armature current. Also, the field strength would be increased rapidly to restore normal terminal voltage on the generator. The study also indicated that with the automatic voltage control, the transient power angle curve could be used to determine the maximum sudden load increase for which the generator would stay in synchronism.

The automatic voltage control equipment consists of a static network which transmits a control signal to a rotating amplifier whenever the generator terminal voltage differs from the value set by the operator. The rotating amplifier is a motor-driven 2-stage d-c generator unit with the control signal supplying the field of the first stage. The output of the rotating amplifier is in series with the main exciter field and bucks or boosts that field in accordance with the control signal, thereby adjusting the generator field voltage to bring about the desired change in generator terminal voltage. Feedback equipment is provided to stabilize the action of the control system.

A minimum excitation feature is included with the automatic control to maintain the generator field current above the minimum required for stable operation of the generator at any load. This feature compares the generator field current with the in-phase component of the generator load current and transmits a control signal to the rotating amplifier if the field current is below the value set for generator stability.

Various tests were made as follows:

1. The amplifier drive motor was switched off with the regulator in service. The generator voltage dropped to the corresponding value of the manually set field rheostat and the rotating amplifier did not motorize.
2. Several rectifiers in the static network were short-circuited one at a time without any noticeable effect on the rotating amplifier output.
3. The potential lead to the static network was removed to simulate the failure of generator potential transformer fuses. The rotating amplifier increased its output 180 volts in the direction to increase the generator field current. Because of this behavior, an alarm was installed to warn the operator when the amplifier output exceeded 50 volts.

When the equipment was placed in service, a field test was made by closing in on a 132-kv line short-circuited 115 miles away. After the first 1/4-second the drop in generator terminal voltage caused the rotating amplifier to increase the exciter voltage. During the transient period while the generator current was increasing due to the fault, a corresponding increase in field current was noticed on the test oscillogram. Before this induced field current decayed, the rotating amplifier had increased the exciter voltage sufficiently to maintain the new value of field current. Further action of the regulator restored normal terminal voltage on the generator.

A number of system troubles have occurred since the automatic voltage regulator has been in service. In each instance oscillograph records show that the regulator operated to maintain normal (18-kv) terminal voltage on the generator and that it remained stable.

The automatic voltage regulating equipment in service at Waukegan Station on a 115-megawatt generator satisfactorily does the following: 1. minimizes the effect of disturbances caused by sudden load changes and fault conditions; 2. controls generator excitation so as to increase safe operating limits; 3. maintains generator terminal voltage within ±0.2 per cent of normal under steady-state load conditions at any fixed kilowatt load setting from 25 per cent to 115 per cent of full load; 4. operates without hunting; 5. provides high rates of excitation voltage response to restore voltage to normal quickly following a disturbance.

Digest of paper 52-34, "Experience with Automatic Voltage Regulation on a 115-Mw Turbogenerator," recommended by the AIEE Committee on Power Generation and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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The Series Capacitor in Sweden

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Swedish engineers have used a series capacitor installation to increase the transmitting capability of a high-voltage transmission line. Their experiences with this installation and its design are described in detail.

THE SERIES capacitor has been attracting interest in recent years as a means for increasing the transmitting capability of a power transmission network. In Sweden an installation (Alfta series capacitor) has been in service in a 230-kv network since January 1950 and others are planned.

In Sweden the opinion is held that it is not economically justifiable to employ intermediate switching stations. Consequently, the selection of the best position for the series capacitor has been less restricted from economic and technical considerations than would have been the case if it were necessary to install it in a given switching station. The opinions advanced in this article must be considered from this point of view.

ECONOMIC POSSIBILITIES

BY THE INSTALLATION of series capacitors in a transmission line the transmitting capability is increased by the value $kP/(1-k)$ megawatts, where the degree of compensation k is the ratio of the capacitor's reactance to the reactance of the line itself and P is the transmitting capability of the line before its compensation.

The series capacitor should be designed with regard to the continuous stresses under normal service. The rated effect in reactive megavolt-amperes then will be

$$P_{cr}=kX\left(\frac{P}{(1-k)E\cos\phi}\right)^2$$

where X is the reactance of the line, E is the line-to-line voltage, and cos ϕ the power factor for the line load at the capacitor. Overvoltages caused by short circuits in the network are limited by protective spark gaps connected in parallel to the capacitor.

The cost for the installation consists of a fixed part and a part which is proportional to the capacitor effect. It appears to be possible in Sweden, with prices that prevailed in January 1951, to reckon with a cost of about $500{,}000+30{,}000P_{cr}$ Swedish crowns (1 United States dollar = 5.2 Swedish crowns). The annual costs are estimated at about 10 per cent, while in Sweden the calculated values are 9.5 per cent for a transformer station and 7.5 per cent for a power line. In addition, the series capacitor changes the load distribution. Thus, when compensating an existing line it is often necessary to reckon with an increase in the line losses which is estimated at 60 crowns per kilowatt per year.

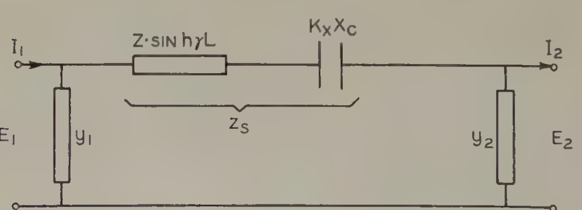

Figure 1. Equivalent circuit for a line with series capacitor

With the series capacitor at Alfta the annual increase in losses amounts to about three times the interest and depreciation on the installation costs. Here the economic optimum lies with 0.2 as the degree of compensation, whereby about 15 per cent is gained compared with the cost that would have been entailed to obtain the same increase in the transmission capability by a new line. At low load on the 230-kv network and simultaneous production of expensive energy, it does not pay to keep this installation in service.

In other cases it may be desirable to change the load distribution to obtain the lowest total losses in the network. This applies particularly when lines for different voltages are operated in parallel, connected through system transformers, and also when a certain line can be strengthened by changing the conductors. In general, it may be said that those lines should be compensated which have a lower resistance-reactance ratio than the others.

In certain cases the series capacitor offers a satisfactory means for increasing the transmission capability of a power line when the maximum capability is only needed during a relatively short part of the year.

If the increased transmitting capability obtainable with series capacitors is taken under consideration when planning the transmission lines and the latter are dimensioned accordingly, it will be found remunerative to compensate all the reactance in excess of that corresponding to a line length of 200 to 250 kilometers at 230 kv and 275 to 350 kilometers at 400 kv which would correspond to a transmitting capability of 300 and 800 megawatts respectively. The costs curve exhibits a fairly flat minimum and considerable deviations are permissible without causing an excessive reduction in the gains. When determining the most favorable degree of compensation, for compensations greater than 0.50, allowance must be made for the fact

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The authors wish to express their thanks to Allmänna Svenska Elektriska Aktiebolaget (ASEA), Liljeholmens Kabelfabrik, and Sieverts Kabelverk for their valuable cooperation. Special reference should be made to the reports of Dr. I. Herlitz of ASEA relating to the economic potentialities of the series capacitor; of Mr. N. Knudsen, ASEA, dealing with special disturbances in series capacitors; and of Mr. S. Ruck, Swedish State Power Board research division, concerning the location of capacitors.

that the capacitor plant must either be divided between two stations or some relay system other than distance protection must be employed.

The series capacitor allows considerably greater freedom in selecting the time for reinforcing a network to carry progressively increasing loads.

LOCATION OF THE SERIES CAPACITOR

THE CHOICE FOR the location of the series capacitor lies between the terminals of the compensated line and a point out on the line.

One might assume that the question of maintenance would favor the installation of the capacitor in a station with attendance and that a suitable site and auxiliary power would be obtained more conveniently at such a point. Experience gained with the Alfta installation shows, however, that permanent supervision is not necessary and may be restricted to inspection at infrequent intervals. Disconnection of the plant is performed automatically on operation of its relay equipment. Auxiliary power is only required on a small scale and does not give rise to any difficult problems.

A point in favor of placing the capacitor out in the line is that the short-circuit current at such places is less than it is in the stations, which facilitates the dimensioning of the series capacitor's protective equipment. Further, a spark gap without forced deionization is then less liable to reignite after a successful high-speed reclosure of the compensated line. The problem of relay protection for the power lines is facilitated when the capacitor is placed in the middle of the line. For degrees of compensation up to 0.5 it is possible to work with standard distance relays which may be supplemented by carrier-current equipment or some similar arrangement. If the degree of compensation exceeds 0.5, the use of two capacitor stations in the line is recommended, whereby distance relays may be used up to the degree 0.67.

In the expression for the rated effect of the capacitor the power factor for the line is included. On long lines operating at the highest voltages $\cos \phi = 1$ is used at the center of the line. On the other hand, one must reckon with an appreciable reactive power fed into or withdrawn from the line at the terminals. As the result of this, the required rated effect will be lowest when the capacitor is located in the middle of the line. The gain may amount to a few per cent.

Owing to wave formation in the line, the capacitor's effective reactance will be less than its rated value. The series impedance Z_s in the equivalent circuit for the line (see Figure 1) consists of two terms of which the first, $Z \sinh \gamma L$, is the usual expression for the series impedance of a line, while the second term, $K_x X_c$, represents the effective reactance of the series capacitor. In Figure 2 the correction factor K_x has been calculated when the capacitor is located both in the center of the line and at one of the line terminals. The effect of the series capacitor will be less when it is placed at the line terminals than when it is in the center. For example, in the case of a line 500 kilometers in length, the series capacitor must be constructed 7.5 per cent larger for the same degree of compensation

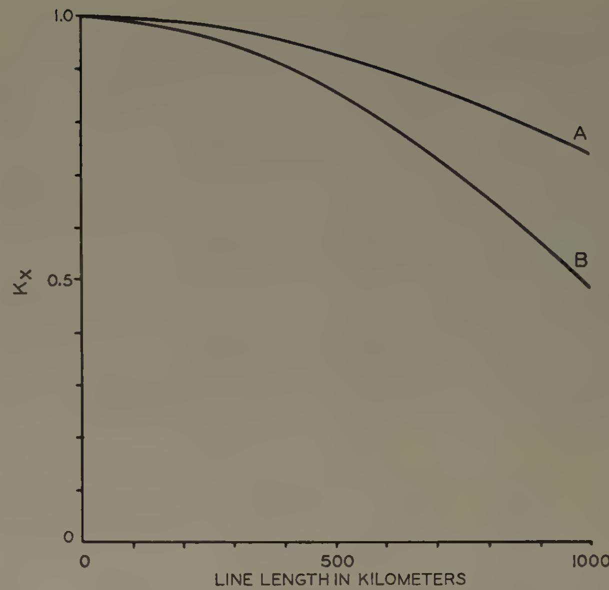

Figure 2. The long-line correction factor K_x for a series capacitor versus the line length. (A) capacitor located at line center, (B) at a line terminal

when it is located at a line terminal instead of at the center point.

WITHSTAND VOLTAGE REQUIREMENTS

WHEN THE COMPENSATED line is connected and takes up maximum load the transient voltage across the capacitor may amount to 2.4 times the bank's rated voltage E_{cr}. Oscillations in the network cause lower overvoltages. This implies that the protective spark gap must have an ignition voltage which exceeds 2.4 E_{cr} with a value of about 2.6 E_{cr}. At the same time it is necessary for the capacitors to be able to withstand this voltage for a short time. On successful high-speed reclosure of the compensated line the spark gap must not reignite at this value.

A more severe demand with respect to the ignition voltage, and therefore the withstand voltage, is normally imposed by the requirement that ignition shall not take place on the occurrence of faults outside the compensated line. Figure 3 shows the estimated conditions for the 230-kv series capacitor at Alfta. It is installed in a transmission line 300 miles in length. The voltage across the bank in the event of faults outside the compensated line is reduced when the degree of compensation is increased. With the selected value of 0.20, 2.6 E_{cr} is obtained, whereupon an ignition voltage of 2.9 E_{cr} was selected for the spark gap. With lines of shorter lengths, higher overvoltages are obtained. In exceptional cases it may be necessary to select spark-gap settings up to 4.5 times the rated voltage.

It was therefore necessary to design a capacitor which is fully utilized at the rated voltage but at the same time is capable of withstanding an overvoltage of 4.5 times this value. Since series capacitors will eventually constitute a normal part of the installations in the transmission network, these capacitors need not be constructed in such a form that they can be utilized for shunt batteries. Extensive research work has been carried out by Swedish capac-

itor manufacturers. In the course of this work it was found that when a capacitor is dimensioned economically for continuous service at the rated voltage, a guarantee can be given for future deliveries that it will have a life of 5 seconds on continuous service at a voltage which is 4 times the rated voltage. In practice it is not necessary to allow for a short circuit of such long duration as 5 seconds in a high-power network, and a time of 1 to 2 seconds should represent a maximum value even when the relay protection or circuit breaker for the faulty part of the plant fails to operate. This corresponds to the life at approximately 4.5 times the rated voltage. Normally, the overvoltages are of much shorter duration, namely, less than 1 cycle on faults causing the spark gap to function, and the time required for the relay protection and circuit breaker to operate, or about 5 cycles, in the case of other faults. According to tests, the capacitors offer a high strength to transient overvoltages of this kind. In actual practice such faults occur in the Swedish network about once or twice a year on the average. Consequently, the opinion is that the resistance to overvoltages guaranteed by the Swedish manufacturers offers adequate security, even if it should be necessary in some special instances to employ an ignition voltage for the spark gap as high as 4.5 E_{cr}.

The spark-gap protection should have an ignition voltage which is selected within the range 2.6 to 4.5 E_{cr}. Ignition should take place without delay, which is facilitated by the fact that the building-up process is determined by a combination of 50 cycles and subharmonics. The tolerances should be kept within narrow limits so that one will not be forced to employ unnecessarily high values. If forced deionization is adopted, this must not give rise to an increase in the ignition voltage on high-speed reclosure against sustained faults. When the spark gap has ignited, it should burn continuously so that the capacitors are not subjected to additional stresses due to charges and discharges in rapid sequence during the course of a disturbance. It should be capable of burning for at least 2 seconds to avoid destruction on faults in the relay protection and circuit breakers for the compensated line.

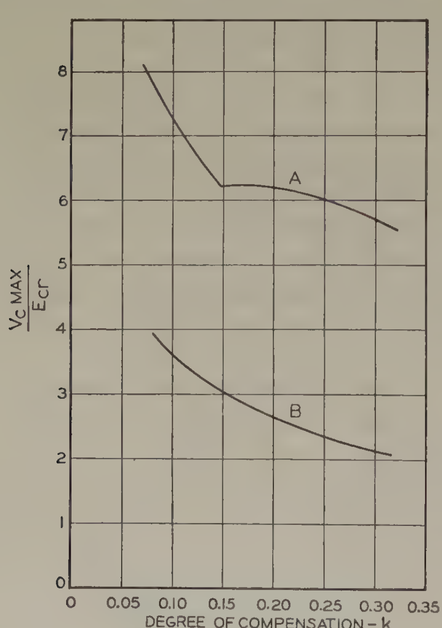

Figure 3. Maximum voltage across the Alfta series capacitor at short circuit on the network, $V_{c,\,max}$, in proportion to rated voltage, E_{cr}. (A) Short circuit outside the compensated line. (B) Short circuit on the compensated line (the maximum voltage stress occurs for $k<0.15$ during the first half-cycle, for $k>0.15$ during the second half-cycle)

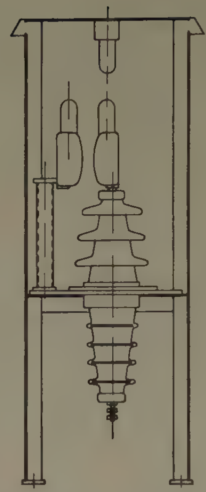

Figure 4. The protective spark gap

When employing high-speed reclosure for the compensated line, it must be deionized sufficiently during a dead interval of 0.20 second to prevent reignition on successful high-speed reclosure, whereby the overvoltage may amount to $2.4E_{cr}$. The spark-gap protection should be simply designed so that it does not require manning of the station.

Figure 4 is a schematic view of the spark gap which was designed by Allmänna Svenska Elektriska Aktiebolaget (ASEA). The flashover is initiated between the spherical surfaces of metal electrodes but is forced up very rapidly to graphite electrodes under the action of electromagnetic forces and the upward flow of air due to the heat generated. The design ensures rapid and reliable ignition with an unchanged breakdown voltage even after ignition has taken place several times, since the arc leaves the metal electrodes so rapidly that practically no burning is caused at the latter. The arc is maintained steadily in the burning position without any tendency to extinction when the current passes through zero. In tests on the Alfta installation it was found that there was a 50-per-cent probability of reignition after successful high-speed reclosure and a dead interval of 0.25 second and a setting of 2.9 E_{cr}. It is expected that by making slight changes in the design it will be possible to obtain a spark gap which fulfills all requirements. In this connection it should be noted that with the new capacitors it normally will be possible to employ ignition voltages of 3.5 to 4 times the E_{cr} value.

THE ALFTA SERIES CAPACITOR

The Alfta installation is to a certain extent an experimental installation. The delivery was divided between the two Swedish manufacturers, ASEA and Sieverts Kabelverk. The system of connection is shown in Figure 5.

The total effect amounts to 31.4 reactive megavolt-amperes at a rated voltage of 20.5 kv and 50 cycles. This corresponds to a degree of compensation 0.2.

The capacitors are of the standard shunt-capacitor type. With a view to the working conditions, however, the delivery tests were somewhat more stringent than those required by the Swedish standards. All units were tested with a d-c voltage of six times the rms value of the rated voltage. Furthermore, the capacitors are guaranteed to withstand three discharges within a space of 2 minutes at a direct voltage of five times the rms value of the rated voltage and an alternating voltage of 3.5 times the rated voltage during 5 seconds.

Figure 6 shows the plant. The capacitors are suspended in a steel framework, allowing for a possible increase in the size of the bank to double the power. The station has been equipped with sky-wire protection but not with lightning arresters. The grounding of the towers has been

improved over 1 mile in each direction of the line, which has two sky wires with a good protective angle.

During the first years of service, overvoltages across the bank have been recorded by means of cathode-ray oscillographs connected to 230-kv capacitors. The relays, control gear, annunciator, and instruments are installed in a building. The signals are transmitted to a power station at a distance of 3 miles. The station itself is unattended.

The protective equipment for one phase is illustrated in Figure 5. Here the capacitors and spark gap are shown.

A protective capacitor is connected in parallel with the spark gap to eliminate any risk of flashover in the gap due to atmospheric overvoltages of steep wavefront. Although the main capacitor itself provides fairly satisfactory protection against such flashovers, owing to the danger of reflection phenomena in the relatively long leads to the capacitor and spark gap the protective capacitor has been connected in the circuit close to the spark gap.

The damping elements reduce the stresses in the gap and the by-pass circuit breaker; they also moderate the stresses in the capacitors on the occurrence of flashover in the spark gap or closure of the circuit breaker. In the absence of special damping, these discharges would give rise to very slightly damped oscillations at a frequency of about 1,500 cycles. The reactor connected in parallel with the resistance provides a path to the closed circuit breaker practically free from losses for the current at the network frequency.

The discharge reactor with its series resistance serves to discharge the capacitor within 0.3 second on the disconnection of the compensated line. In this way the risk

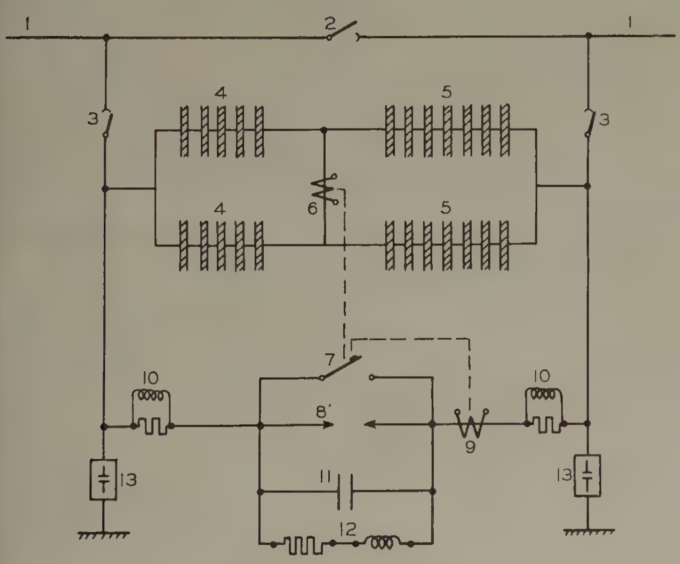

Figure 5. Schematic single-line diagram of the Alfta series capacitor and its protective equipment

1. 230-kv line. 2. by-pass switch. 3. disconnecting switch. 4. group of Sieverts capacitors, 160 units each of 23 kilovars at 1.81 kv. 5. group of ASEA capacitors, 91 units each of 32 kilovars at 1.63 kv. 6. current transformer for feeding equipotential protection. 7. by-pass circuit breaker. 8. protective spark gap. 9. current transformer for feeding current relays. 10. damping resistance. 11. capacitor to prevent the gap from igniting at transient surges. 12. discharge reactor. 13. capacitor for feeding supervision oscillograph

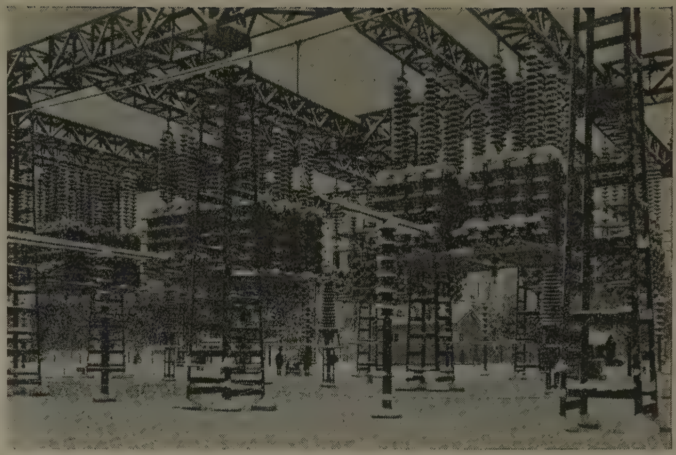

Figure 6. The series capacitor plant at Alfta. In front are the Sieverts groups, in the rear the ASEA groups

of flashover in the gap on the reconnection of the line is reduced.

The circuit breaker is intended primarily for connecting in and disconnecting the series capacitor. In addition, it serves to automatically short-circuit the capacitor and protect spark gap on the occurrence of faults in the capacitor units or on the abnormal functioning of the spark gap. A 46-kv minimum oil circuit breaker is employed. Each pole is mounted on the platform for the corresponding phase, also supporting the spark gap, protective capacitor, and discharge reactor. The operation is 3-phase, the mechanism being actuated by a motor-operated gear placed at ground level and connected to the circuit-breaker poles by means of rotary insulators.

The isolating switches are employed for the complete disconnection of the station. Normally, all three of them are operated manually with the circuit breaker closed. As a stand-by in the event of the circuit breaker failing to close, a motor-operated closing mechanism is also provided for the by-pass switch.

Single-phase faults to ground and polyphase faults in the capacitor installation will cause the normal relay protection at the line terminals to function.

The capacitor units in each phase are arranged in four groups in the same way as in a Wheatstone bridge. A current transformer is connected in one diagonal and feeds a sensitive current relay which reacts to unbalance set up by faults in a capacitor unit. The current relay transmits a definite closing impulse to the by-pass circuit breaker by way of a time-lag relay in each phase set for 1 second and an auxiliary relay common to all three phases. The time lag ensures that unwanted operation of the relay equipment will not cause closing of the circuit breaker due to short circuits in the compensated line, discharge currents on by-passing of the capacitor by the spark gap, or transient phenomena on connecting in the bank.

The current through the gap and by-pass circuit breaker flows through a 3-phase set of current transformers which feed current relays operating at about 25 per cent of the maximum line load. These are included as the starting element in an automatic mechanism. Normally, the spark gap only ignites on the occurrence of faults in the com-

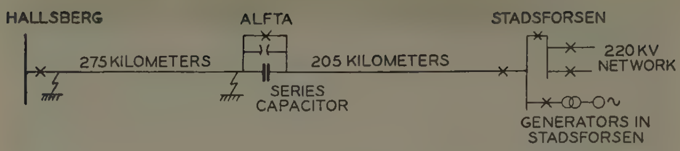

Figure 7. Schematic of the test system. The crosses signify circuit breakers

pensated line, whereupon the line is disconnected at the terminals after 0.15 second and is reconnected automatically after a dead interval of 0.4 second. The automatic mechanism will not be affected here, as the current relays work through a time-lag relay with a setting of 0.5 second. Should the spark gap reignite in consequence of insufficient deionization, the circuit breaker will close after 0.5 second so that no current will flow in the gap. The circuit breaker will open again after 6 seconds. If the spark gap reignites then, the circuit breaker will close definitely. When the circuit breaker is opened by the control switch or by hand it will only be closed again definitely by the automatic mechanism.

If for some reason the circuit breaker fails to close on the occurrence of a flashover in the spark gap, the capacitor and the gap will be short-circuited by the by-pass switch, which is equipped with motor-operated gear. This will take place after the gap has burned for about 4 seconds.

Two current transformer sets of the 230-kv type were chosen so that the relay protective equipment and other supervisory arrangements may be at ground potential. The only connection required between the ground level and the 230-kv equipment consists in the operating rods for the circuit breaker.

TESTS ON THE SERIES CAPACITOR AT ALFTA

The series capacitor at Alfta was placed in service in January 1950. As the installation is the first of its kind it was considered desirable to subject it to extensive field tests. In the case of future installations it should not be necessary to undertake tests on the same extensive scale.

A testing system of the kind shown in Figure 7 was employed. Short circuits were initiated through thin silver wires applied between the phases and ground in a test tower close to the bank. The voltage was applied through the line circuit breaker at Stadsforsen which also was required to disconnect the faulty line.

During the first series of tests the line was fed exclusively by the two generators at Stadsforsen. According to the theoretical calculations a voltage of approximately the same magnitude (80 kv) should be obtained across the series capacitor as with a short circuit immediately outside the compensated line under normal service connection. As anticipated, the spark gap did not ignite. An oscillogram of the current in one phase and the voltage across the capacitor in the same phase is shown in Figure 8. A damped subharmonic is clearly visible. The voltage crests have not reached the calculated maximum value, which is due to the fact that the short circuit was initiated when the voltage to ground was close to its maximum value. The amplitude of the subharmonic is here only about 40 per cent of the theoretical maximum value.

During a second series of tests the short circuit was fed from the whole network at Stadsforsen when the available short-circuit power was 4,000 megavolt-amperes symmetrical. Figure 9 shows the line current and voltage across the three phases of the capacitor. The spark gap ignited in two phases simultaneously when the voltage reached the set value of 85 kv. The third phase was subjected to a short-circuit current somewhat later owing to a time difference between the three poles of the Stadsforsen circuit breaker. The upmost record shows the current in one phase of a current transformer connected between the two branches of the bank. At the discharge a transitory current is obtained in this circuit and, consequently, the equipotential protective gear fed from this source was given a time lag.

In a third series of tests the conditions were reproduced which occur on the successful automatic reclosure of the circuit breakers following a fault on the compensated line. The result was that reignition occurred in half the number of cases with a 0.25-second dead interval. For the time being the dead interval has been increased to 0.40 second, at which there is no danger of reignition.

OPERATING EXPERIENCES

The series capacitor at Alfta has been connected to the network for two years. During this time the station never has been disconnected automatically from the line on any single occasion, either owing to capacitor faults or flashovers in the spark gap. The 1,150 units forming the capacitor bank have been measured several times without the measurements disclosing any changes in the capacitors.

No short circuits have occurred during this period in the compensated line. On the other hand, a number of lightning disturbances have taken place in other parts of the 230-kv network. Some of these have caused the system to fall out of phase and have given rise to a total breakdown in the network. In these conditions the cathode-ray oscillographs have recorded moderate overvoltages across the series capacitor. The load current in the compensated line on certain occasions has exceeded the rated value of the series capacitor by up to 10 per cent.

As mentioned earlier, the switching on of the series capacitor at Alfta increased the transmission losses. It is

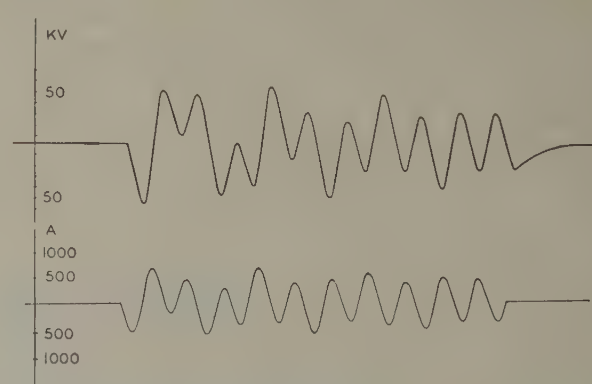

Figure 8. Oscillograms showing the voltage across series capacitor and the current in compensated line at conditions corresponding to a short circuit outside the compensated line

of interest, therefore, to disconnect the capacitor from time to time. In the course of the winter of 1950 to '51[1] the capacitor was disconnected for long periods. On numerous occasions it was cooled down to temperatures of about −30 degrees centigrade and since it is entirely unprotected it also was exposed to severe climatic conditions including ice and snow. Notwithstanding this fact, the bank could always be switched on again without disturbances or preparatory work of any kind.

Ferromagnetic subharmonics and similar disturbances have not been observed at normal service or during disturbances in the network. In certain operations, however, it is desired to energize the compensated line from one terminal, Stadsforsen, with a reactor-loaded transformer connected to the other terminal. Tests have shown that a remaining seventh subharmonic is obtained in the line current of about 60 amperes rms value. This should not be dangerous for the transformer but it makes synchronization difficult and it cannot be tolerated from an operational point of view. It has been decided to complete the installation with automatic relay equipment which is sensitive to subharmonics and which at their occurrence by-passes the series capacitor for a short time interval.

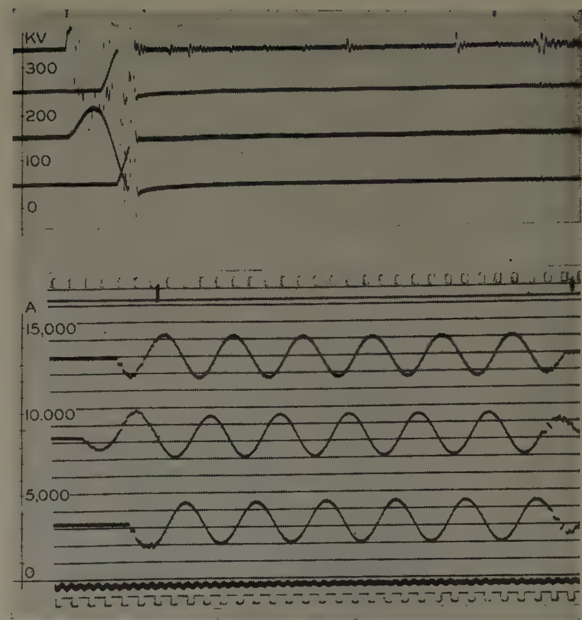

Figure 9. Oscillograms showing the voltage across series capacitor and the currents in compensated line at short circuit on compensated line. The upper record shows the current in the equipotential protection

PLANS FOR NEW SERIES CAPACITORS

The experiment with the series capacitor at Alfta is considered to have been quite successful. For this reason series capacitor compensation is being considered as a possible alternative in the majority of cases relating to the future reinforcement of the Swedish high-power network.

Proposals thoroughly discussed have been advanced for a number of 230-kv installations, but so far no decisions have been taken. This is chiefly due to the rapid extension of the Swedish 400-kv network. The 400-kv lines will have a ratio of resistance to reactance which is appreciably lower than that for the parallel-connected 230-kv lines. Accordingly, the 400-kv lines should come into consideration as regards series capacitor compensation primarily if it is desired to obtain the most favorable load distribution.

Investigations show that the first Swedish 400-kv series capacitor should be combined with the starting up of the second 400-kv line, running from the north to central Sweden, and should be located in this line. Measurements made with a network analyzer actually show that a 0.3 compensation for this line would reduce the network losses by 6 to 7 megawatts even when the line is first placed in service. This reduction in losses alone would entirely pay for the series capacitor, which would have a rating of the order of 100 reactive megavolt-amperes. At a later stage, however, the most favorable degree of compensation for this line would be considerably higher.

CONCLUSIONS

1. By the installation of series capacitors in a transmission line the transmitting capability is increased by the value $kP/(1-k)$ megawatts, where k is the degree of compensation and P is the transmitting capability of the line before its compensation. The installation is most remunerative in lines with a low resistance-reactance ratio.

2. For new lines the degree of compensation should be so selected that the power transmitted per line amounts to about 300 megawatts at 230 kv and 800 megawatts at 400 kv.

3. On economic and technical grounds the series capacitor should be located at the center of the line when the degree of compensation is less than 0.50. For higher degrees the compensation should be spread over a number of plants.

4. The capacitor units must be so dimensioned that they are fully utilized with normal full load on the line. They should withstand temporary load peaks.

5. The capacitor units should be capable of withstanding overvoltages of a given magnitude for a short time. They are protected by spark gaps against higher overvoltages which may be set up on the occurrence of short circuits on the compensated line.

6. The annual costs for maintenance of the first Swedish 230-kv plant has been about 1 per cent of the capital costs.

7. Swedish plans have been drawn up for the installation of further series capacitors in the transmission and distribution systems. Consideration is being given to a special design of capacitor for series capacitor service.

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Series Capacitors in High-Voltage Lines of the Bonneville Power Administration

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SERIES CAPACITORS in high-voltage transmission lines are used by the Bonneville Power Administration for two fundamental purposes:

1. To change relative reactances of two or more parallel circuits to produce the desired division of loading between the circuits. This may be desirable when conductors of different cross sections are employed in circuits between the same terminal busses (Rocky Ford installation). Indirectly such capacitors decrease transfer reactance between the two busses and improve voltage conditions and stability of the system.

2. To decrease the transfer impedance by compensating a certain part of the line inductive reactance, thereby increasing the synchronizing power between the sources of electromotive force and improving the steady-state and transient stability of long-distance transmission systems (Chehalis installation). Indirectly such capacitors improve voltage conditions of the system.

Two large series capacitor banks of the Bonneville Power Administration's transmission lines are described to point out some of the problems encountered with such installations. Particularly important is the protection against overvoltages caused by fault currents.

As with every series device, the line series capacitor bank must either withstand maximum current in the circuit (usually short-circuit current) and the corresponding voltage across the capacitors, or must be protected. Although it would be feasible to manufacture static capacitors withstanding such higher voltages for the short times required for the operation of modern relays and circuit breakers, for economic reasons it was desirable to use standard, or "off the shelf," power capacitors of standard voltage rating. As it would be uneconomical to require series capacitors to withstand high voltages for short fault duration, the alternative of a protective gap across the capacitors was chosen. The setting of this protective gap, that is, its spark-over value in terms of rated voltage, is determined by the short-time characteristic of capacitors. Average conservative values are recommended in a report by the Working Group of the AIEE Capacitor Subcommittee of the Transmission and Distribution Committee.[1] Figure 1 was taken from this report and gives the values of permissible overvoltages across standard capacitors as a function of the time during which the overvoltage exists.

To avoid capacitor overstress and yet prevent repetitive gap operation or "machine gunning," a gap setting of $2^1/_2$ times normal was selected as the most appropriate. An elementary analysis indicates that transient voltages across series capacitors, through which normal rated current is being established, may reach double normal value.

Although to establish an arc across the protective gap a voltage $2^1/_2$ times normal is required, the arc will be maintained by a small fraction of this voltage. The ideal gap would be a self-quenching gap which would stop the flow of current through it when the current in the circuit and therefore the voltage across the capacitor bank is reduced to rated value. So far as is known, no one has been able to build such a self-quenching gap for currents of the required order and so some means should be incorporated to extinguish the arc in the gap and thus to reinsert the capacitors, that is, to make the line current resume its flow through the bank.

CHANGING RELATIVE REACTANCE

THE INSTALLATION shown in Figure 2 is designed for a new third circuit with conductors the cross section of which (in circular mils copper equivalent) is about 60 per cent more than conductors of two older parallel circuits with practically the same values of reactance and connecting the same busses. The necessary compensation was calculated to be 25 per cent of the reactance of the new circuit and series capacitors are used for this purpose. If the compensated circuit is faulted, it will be isolated by terminal circuit breakers and then, with no current flowing through the gap, the arc will be extinguished. The high-speed reclosing circuit breakers then will re-energize the switched-out section of the circuit together with its capacitor bank and protective gap. Unless sufficient time has elapsed for appropriate deionization of the gap, the transient overvoltage associated with the resumption of current flow through the capacitors may trigger the gap and, by re-establishing the arc, will short-circuit the capacitors. To be certain that this will not happen, the dead time of reclosure must be prolonged and, unless there is a very liberal number of parallel circuits, this prolongation is a factor unfavorable for optimum system operation.

The experience with a plain-gap installation in Sweden substantiates this requirement of prolonged dead time of reclosure. "After repeated tests it was confirmed that reignition occurred in about half the number of cases with a 250-millisecond dead interval, despite the fact that

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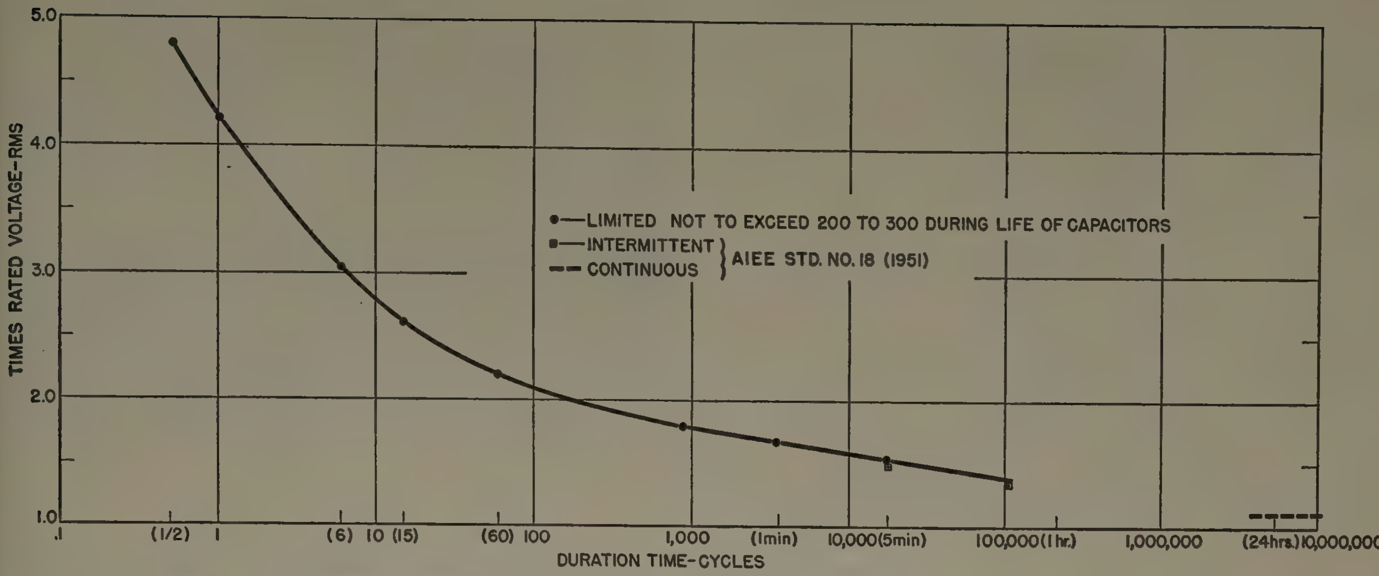

Figure 1. Permissible short-time 60-cycle overvoltages above continuous rating for standard capacitors

the voltage across the bank did not exceed half the normal breakdown voltage for the spark gaps. Thus, the latter had not had time to become sufficiently deionized. For the time being the dead interval has been increased to 400 milliseconds at which there is no danger of reignition under normal circumstances."[2] This quotation illustrates one of the reasons why the Bonneville Power Administration prefers the air-blast principle for extinguishing the arc and scavenging of the gap space. It is desired to eliminate quickly the ionized hot gas and to avoid prolongation of the reclosing time.

With higher degrees of compensation in regions of high short-circuit current it is possible that faults in adjoining line sections will produce flashover of the gap in the unfaulted compensated section. Then since only the circuit breakers in the adjoining section will operate, and not those in the section where capacitors are located, there is nothing to interrupt the arc in a plain gap. For such cases some other means to extinguish the arc must be available and it is believed that air blast at present is the most appropriate. Furthermore it will serve in certain other conditions of series capacitor application better than some other slower, mechanical means.

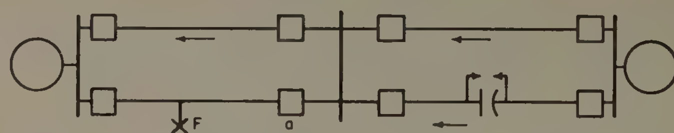

Figure 2. Distribution of loading between parallel circuits

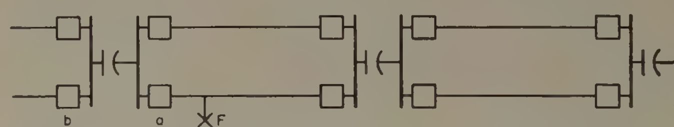

Figure 3. Capacitor bank common to two circuits and installed at sectionalizing substations

REACTANCE COMPENSATION

If it were not for the relay problem the location of series capacitors for the first type of application is relatively immaterial—they may be at the sectionalizing substations or in the middle of the line sections—but for the second type (Figure 3) the considerations of economy dictate that in the usual 2-circuit line the capacitors must be in the substation itself and must remain in the circuit even when the faulted section of one of the circuits is switched out.

The Bonneville Power Administration network is the major part of the interconnected electric power transmission system spread through the four Pacific Northwest states and extending into British Columbia. One of the fundamental engineering problems, therefore, is to maintain transient stability of the integrated system. Faced with the problem of some very long transmission lines (400 to 500 miles) it was decided to improve the synchronizing power by decreasing the transfer impedance. This can be accomplished by compensating part of the line inductive reactance by means of series capacitors. The decrease of transfer reactance is particularly important right after a fault is cleared and the sources of the electromotive force in the system (synchronous machines) are swinging. Any remedial measures to decrease the amplitude of the swings and to keep the machines in step must become effective within a few cycles and these measures are the more effective the sooner they are applied. If as a result of a fault in a section of the transmission line the protective gap across a series capacitor bank at the near substation is flashed over and an arc is established, this arc will be maintained even after the faulted line section is isolated. The arc which short-circuited the capacitor bank eliminates its reactance compensating effect just at the time that this effect is most necessary.

To make capacitors of maximum value the protective arc must be extinguished and the capacitors reinserted into the circuit within a half-cycle after the fault is isolated. This is accomplished by using an air blast through the gap. Within 2 or 3 cycles after the initiation of a fault the air

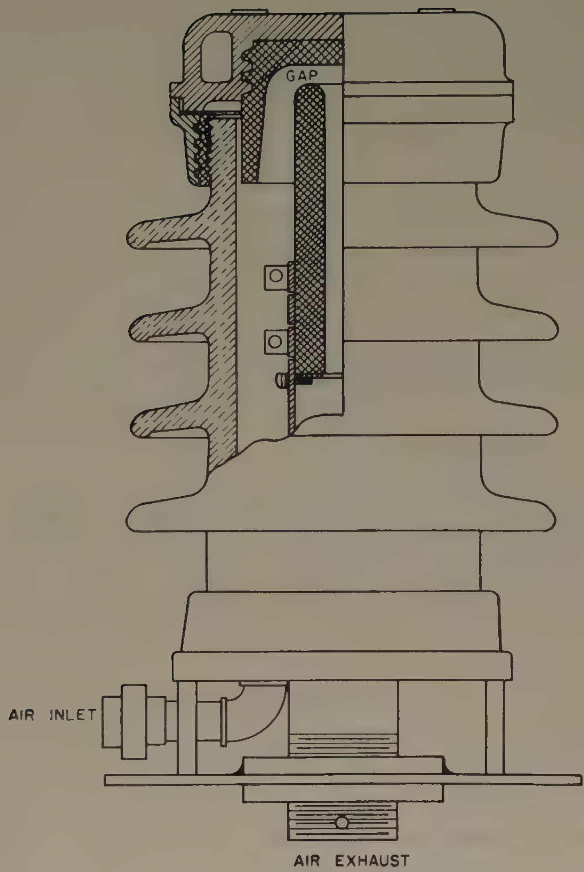

Figure 4. Cross section of the air-blast gap

valve on the enclosed gap opens, creating a blast which extinguishes the arc each time the current passes through zero. If short-circuit current still flows and overvoltage across the capacitors exists, the gap reignites and repetitive extinguishing and reignition continues throughout the duration of the fault. When the fault is isolated by opening of line circuit breakers of the faulted section, the current through the capacitors decreases and therefore voltage across the gap becomes lower than the flashover value. After the arc current is interrupted in passing through the next zero the voltage across the capacitor will not reignite the arc because the gap now is scavenged thoroughly. This type of equipment is installed at Chehalis Substation.

THE PROTECTIVE AIR-BLAST GAP

A CROSS SECTION of the gap is shown in Figure 4. The porcelain-clad gap is mounted on the top of a compressed-air tank. On top of each gap is mounted a wound resistor which is connected in series with the gap. The purpose of this resistor is to decrease the inrush of current through the arc at the moment the charged capacitors are short-circuited through the arc. This resistor acts also as a damping resistor in the oscillating circuit consisting of capacitors, arc, and the very small inductance of the circuit.

In parallel with the air-blast gap is a plain gap set for flashover at about three times normal voltage to serve as an emergency backup for the air-blast gap.

An over-all protective switch parallels the two gaps as shown in Figure 5. This automatically closed switch is to prevent: 1. long-time operation of the series capacitors under overloads that are not sufficient to operate the protective gap; 2. continued operation when for some reason the air pressure is lost and the air-blast gap protection is not available; and 3. operation of the gap and of the resistance in series with it for durations longer than 15 cycles, indicating that for some reason the fault-isolating circuit breakers or other protective devices did not operate.

This switch is therefore an over-all protective device which is closed by a spring and opened by air pressure. Dumping the air allows the spring to close this switch across the bank for any of these conditions and can be initiated either by a voltage relay with delay adjusted in conformance with the curve in Figure 1 for condition 1 or by delayed current relay for condition 3.

CHEHALIS INSTALLATION

IN THE INITIAL installation at Chehalis, Figure 6, 15-kva 7,960-volt individually fused capacitor units, parallel-connected in a bank of 5,000 kva per phase, are subdivided in two groups. Each group is placed in a ventilated metal cubicle and the two cubicles per phase can be connected in series (rated current $I=312$ amperes; $X=50$ ohms) or parallel ($I=624$ amperes; $X=12.5$ ohms). Each cubicle has its independent protective equipment. Cubicles are on platforms supported and isolated from ground by columns of five pedestal insulators each. The protective equipment is located partly in the end sections of the cubicles and partly (gaps and the gap resistors) between the cubicles. The air compressor is on the ground and the motor is supplied from station service. The compressed air, after being dried, is brought to the air tanks on the insulated platforms through very high resistance coiled rubber hose. This hose, together with two others of identical construction, one for control of air operation of the over-all protective switch and the other for indication of switch position, is located within porcelain columns (one per phase) filled with insulating gum to prevent moisture condensation on the inside walls of the column and on the surface of the hoses.

ROCKY FORD

THIS INSTALLATION, shown in Figure 7, is now being constructed and differs from the original Chehalis installation in the following respects:

The total capacity is 90,000 kva, 30,000 kva per phase, made of 25-kva 4,160-volt individually fused units distributed in three series-connected 10,000-kva groups.

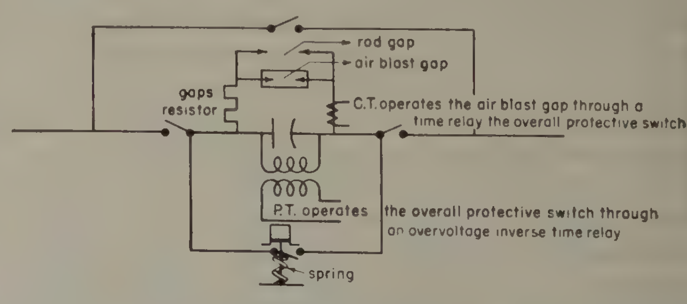

Figure 5. Over-all automatic protective switch and isolating disconnects

Figure 6. Series capacitor installation at Chehalis

Each group in turn consists of two series-connected subgroups of 200 parallel-connected 4,160-volt units. Each of these 5,000-kva subgroups is provided with its own protective air-blast gap, altogether making six gaps per phase.

Rated current of the bank is 1,150 amperes; reactance is −20.3 ohms per phase.

The voltage of the capacitor units (4,160 volts) and the subdivision of 10,000 kva per phase in three separate groups protected by individual gaps are dictated by the ability of these gaps to handle the discharge of the group when the capacitors are short-circuited by the arc.

The capacitor units are not in cubicles but in open racks and, in order not to eliminate the possibility of operating this circuit at 287 kv, if necessary, the platforms are insulated from ground by stacks of 6-pedestal insulators. To simplify the compressed-air system for the air-blast protective gaps, each phase has its own air compressors located on the same platforms as the capacitors, thus eliminating the insulating tubes and porcelain columns necessary if one compressor at ground potential is used to serve all three phases as in the Chehalis installation. The compressor motors are energized by voltage drop across the capacitors and, as this voltage is variable and depends upon the line load, the motors are designed to operate over a voltage range of 4 to 1. If for some reason the over-all protective switch is closed, the bank must be de-energized and the switch reset manually. The closed switch position is indicated by a mechanical indicator and zero voltage on the voltmeter connected across the affected group.

A similar installation but of 46,000 kva is being provided for a third circuit between Grand Coulee and Columbia Substations of the Bonneville Power Administration.

RELAYING

Series capacitor banks represent lumped line capacitive reactance and disturb the distance-reactance relation which is employed by the most widely used reactance-distance relays. The degree of such disturbance depends upon the ratio of line and capacitive reactance and upon location of the capacitors. If the compensation is less than 50 per cent and the capacitors are near the center of the line then the reactance-distance relays should operate correctly. Tests on the Bonneville Power Administration system, however, indicate that even if the capacitors are located at the substation, as at Chehalis, the distance relays operated correctly. This may be explained by the character of the arc gap operation. When, as a result of a fault on the line, the protective gap arcs over, the secondary current of a current transformer in the gap circuit operates a valve admitting air to the blast gap. There is no air flowing and therefore no arc interruption during the first 2 or 3 cycles. This means that during a short interval the arc short-circuits the capacitors, eliminates them from the distance-reactance relation, and the fast reactance-distance relays have time to operate correctly. Simultaneously phase comparison relays were tested and their operation was found to be proper. Only longer operating experience will show whether any additional measures or modifications in the relay protection will be necessary.

INSPECTION AND MAINTENANCE

For inspection and maintenance the whole installation must be isolated from the line and grounded. A 3-pole disconnect switch (Figure 5), when closed, by-passes the bank, and two additional disconnects, one on each side of the bank, then may be opened to isolate the installation. Grounding switches are provided to ground the whole structure. For maximum safety there is a sequential interlock between all three disconnects, the grounding switch, and the gate of the fence around the installation.

SERIES CAPACITORS FOR SYNCHRONOUS MACHINES

For normal operation of a synchronous condenser, its excitation system is designed to maintain bus voltage for comparatively small and slow voltage deviations. The transient reactance of the machine is not of particular importance and the most economical design of the machine may be selected, resulting in transient reactance of about 40 per cent for air-cooled machines and about 60 per cent for hydrogen-cooled machines.

The conditions are different in case of unavoidable disturbances. The ability of the condenser (particularly located at intermediate points of the system) to keep its terminal voltage as high as possible and to supply the system quickly, even if for a short time (about 2 seconds), with an increased amount of reactive kilovolt-amperes is a valuable contribution to maintenance of stability after

Figure 7. Series capacitor installation at Rocky Ford

the fault on the system is cleared and the synchronous machines of the interconnected system are in the process of swinging.

With the relatively high internal electromotive force established during the pretransient conditions as a function of terminal voltage, kilovolt-ampere load, and machine reactance, an instantaneous change in the reactive output of the machine can be accomplished by changing suddenly its equivalent reactance. This change can be effected by inserting between terminals of the machine and the bus a certain amount of series capacitors normally short-circuited by a circuit breaker which opens for a short time when the increased kilovolt-ampere output is required and then closes again.

The circuit breaker should not open during the fault but right after the fault is cleared and the system is in the process of swinging. Therefore, the circuit breaker does not have to be faster than about 4 cycles and should reclose in about 2 seconds. Both of these times should be adjustable.

The value of reactance of these series capacitors is determined by the permissible degree of compensation, that is, equal to or somewhat less than subtransient reactance but definitely less than transient reactance. The current carrying capacity or the voltage across the capacitors may be at least twice rated value because these capacitors will be in the circuit for only about 2 seconds.

It is believed that this method of decreasing the reactance of the synchronous condensers during the short time that it is necessary is just as effective and more economical than building low-reactance machines. The cost of static capacitors per kilovolt-ampere is slightly less than half the cost of synchronous condensers and, in addition, since the series capacitors in this application are in the circuit only about 2 seconds, they can be operated at currents and voltages at least twice normal on capacitors that are tested at double voltage for one minute.

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Radio Dispatching System for Operation of a Large Taxicab Fleet

A. R. VALLARINO S. W. LEWINTER

The dispatching of taxicabs by radio has proved to be practical and economical but due to the shortage of radio-frequency channels assigned to this service by the FCC interference difficulties have been experienced. Solutions to this problem are offered by means of frequency and space allocations.

THE SHORTAGE OF radio-frequency channels has been one of the major impediments to use of radio dispatching in large taxicab fleet operations. There is an upper limit to the number of taxicabs that can be handled as a group on one radio-frequency channel. The exact number depends on the type of control used in the system.

To use radio successfully for a large taxicab fleet, the communication load must be divided into noninterfering groups. If the division is attempted by assignment of separate frequencies to each group, then the number of frequencies required usually exceeds the number presently assigned to taxicab radio service by the Federal Communications Commission (FCC). Methods of dividing the communication load of a single radio-frequency channel on a geographic basis by means of directional antennas are known. These are never entirely satisfactory since the directivity patterns that can be obtained are never sharp or stable enough, and interference in boundary regions is inevitable. Moreover, reflections from neighboring objects aggravate this interference.

This article develops methods of frequency and space allocations whereby a taxicab fleet of any size can be served by an interference-free radio system using not more than four radio-frequency channels. In most cases, only three channels are required and in many cases two are

Full text of paper 52-67, "A Radio Dispatching System for Large Taxicab Fleet Operation," recommended by the AIEE Committee on Special Communications Applications and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Not scheduled for publication in AIEE *Transactions*.

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adequate. These solutions are practical from both technical and economic considerations. It is believed that the methods described are of fundamental importance and of sufficient generality to be of value in dealing with communication problems of any large taxicab company.

Four practical solutions requiring either two or three radio-frequency channels and combining geographic and frequency subdivision of the communication load are described. The particular solution that would be most appropriate will depend on local conditions.

Each mobile equipment is designed for the number of frequencies required by the system so that the driver can select any one of them by means of a switch. The city is divided into areas that are so arranged that no interference zones exist when each area is assigned the proper frequency. See Figures 1 and 2. Each area contains a base-station transmitter and receiver with their antennas. Land-lines connect these stations to the main dispatching office. Whenever a driver crosses an area boundary, he switches to the correct channel for the new area. As many radio dispatchers as there are areas can be used during busy periods. The force can be contracted during slow periods by combining the operation of several areas under one dispatcher.

As examples of the potential opportunity for radio in the taxicab field, there are the 600 fleet cabs in Pittsburgh, 2,000 fleet taxicabs in Philadelphia, approximately 13,000 fleet taxicabs in New York City, and about 50,000 fleet taxicabs in the country.

LIMITATIONS OF PRESENT RADIO DISPATCHING SYSTEMS

A study was initiated about a year ago to determine whether we could propose for the large taxicab fleet operators a radio dispatching system using the limited number of radio-frequency channels allocated to the taxicab service by the FCC. It was intended that the study should bring out clearly the differences between the communication problems of the small taxicab operators now using radio dispatching and the largest taxicab fleets not so doing at the time the study was begun. The results were expected to prove of assistance in the design of radio dispatching and control systems for the largest taxicab fleets.

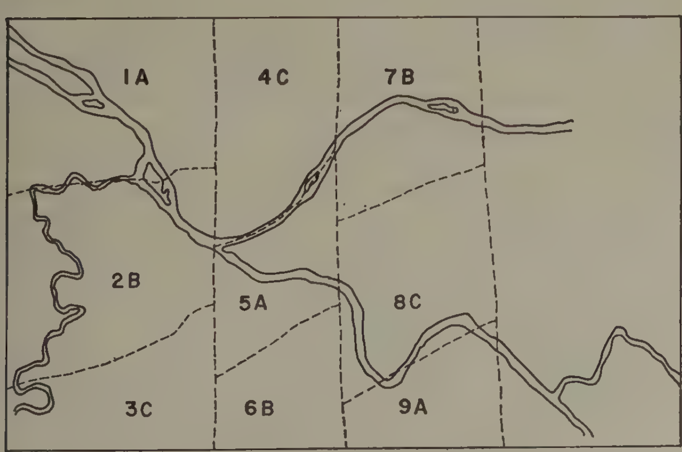

Figure 1. Division of an area for operation with three radio-frequency channels. The sectors are numbered and the channels are lettered

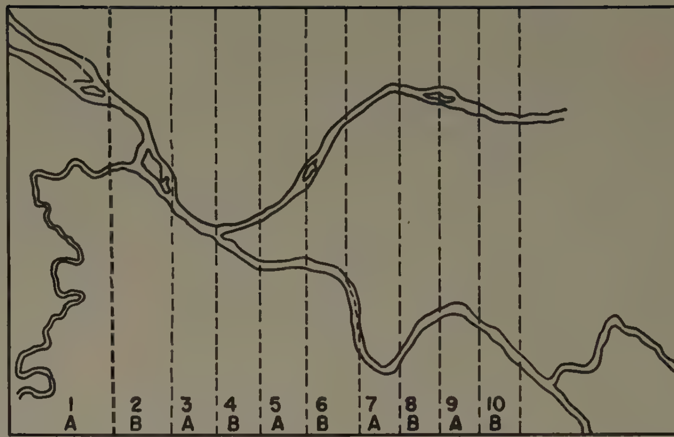

Figure 2. Division of area of Figure 1 for operation with two radio-frequency channels which are lettered and the sectors numbered

At the present time, radio is used mostly by taxicab companies having fleets of fewer than 125 cabs. Beyond this point, the difficulties of dispatching cabs by radio multiply rapidly. The technical problems posed by these larger operations center about the dispatcher's capacity to retain large amounts of continually changing information and the shortage of radio-frequency channel space allocated by the FCC to the taxicab industry.

A description of the operating methods of a typical small radio-controlled taxicab fleet will show why it is not possible to extrapolate directly to obtain operating procedures for the largest fleet operators. This company operates a fleet of 50 radio-controlled cabs. The dispatching is handled by two operators using a single radio-frequency channel. One of them receives incoming telephone requests for taxis and relays the information on slips of paper to the radio operator. The radio dispatcher calls the vacant cab that is closest to the location of the pickup and records the information on a slip of paper of another color. Both slips are filed on a board which contains numbered receptacles corresponding to the cab numbers. These slips are a record of the position and status of every cab in the fleet. The number of cabs that can be handled with this system is limited by the ability of the dispatcher to avoid a nervous breakdown on rainy days when everyone wants a cab. Either human or channel load capacity or a combination of both will limit the extension of such a system to fleets of several hundred cabs.

A radio communication system to meet the needs of a metropolitan cab company of 350 cabs will be outlined. The experience of several taxicab operators using radio systems in which the detailed movements of the fleet are controlled will be used in planning the proposed system. Under normal traffic conditions, one unassisted dispatcher is capable of controlling a maximum of about 70 cabs; at the busiest times, this number shrinks to about 35 cabs. If the dispatchers work independently, each assigned to a sector having approximately the same number of cabs, ten dispatchers and ten channels will be required to handle

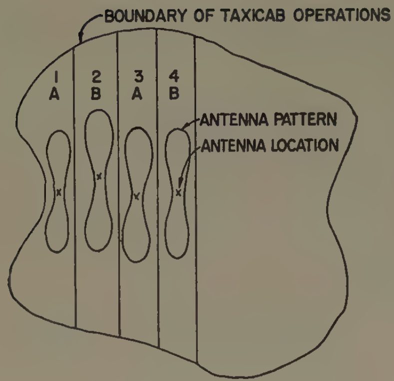

Figure 3. Trapezoidal pattern of space with numbered sectors and frequency allocations, which are lettered, using two radio-frequency channels

peak loads. The term "channel" as used here does not necessarily mean ten 2-way frequencies. A channel is any device by which calls from base stations to mobile units and mobile units to base stations can be segregated into mutually noninterfering groups. In considering the general problem of radio dispatching to taxicabs, channels can be obtained either by frequency or space allocation, the latter to be accomplished by directive antennas. Combinations of the two methods are often the most practical solutions to the channel problem. In any of these methods, ten channels require ten base-station installations.

DESIGN OF INTERFERENCE-FREE SYSTEM

THE RADIO COMMUNICATION load for the given example must be divided into ten approximately equal parts to permit the handling of the necessary volume of messages. One way of accomplishing this is to use frequency allocation and to transmit over the entire city from ten base stations on ten radio frequencies and have one-tenth the cabs receive a given frequency. To divide the incoming messages, ten cab transmitting frequencies are needed with ten receivers used at the base station. In calling a given cab the dispatcher must transmit at the frequency to which the receiver in that cab is tuned and he must expect an answer from the proper base-station receiver. This method is impractical since it requires ten duplex channels, more than the total number presently assigned to the taxicab radio service by the FCC.

The other extreme in dividing the communication load is space allocation. One duplex channel is used with the city divided into ten areas in which the volume of cab business is approximately equal. By the use of selected transmitting sites and directional antennas, an attempt is made to restrict the coverage of each base station to the assigned area. The same antennas are used to receive the taxicab transmissions. By this means and also by restricting the power radiated by the cabs to as small a value as is consistent with reliable operation, the messages from the cabs are divided into ten groups. This method always results in a certain amount of interference in the boundary zones between areas. The directive patterns of the antennas cannot be made sharp enough to prevent overlap; moreover, there are reflections from buildings and other topographical features that produce interference zones.

A combination of frequency and space allocation can result in a system which is efficient in the use of radio-frequency channels and yet does not create zones in which the transmissions from the various areas interfere with each other. The region served by the taxicab company is divided into ten areas. Each area has a base-station transmitter with antenna pattern and power adjusted to confine the radiation into that area plus a small amount of overlap into adjacent areas. The base stations in adjacent areas transmit on different frequencies and these stations are also designed to cover their areas plus some overlap. A mobile receiver in the boundary zone between adjacent areas can receive either base station, but they will be received on different frequencies. The cab receiver and transmitter must be designed for multichannel operation so that the driver merely throws a switch the moment he crosses the boundary line.

Each base station also contains a receiver that is tuned to the channel used by the taxicab transmitters when they are in that area. The base receivers are connected to the same antennas as the base transmitters through an antenna relay, or they are connected permanently to separate antennas having the same directive properties.

The boundaries between areas are marked off on a map and the drivers can be required to memorize the boundary locations. A driver crossing an area boundary would notify his dispatcher and then switch over to his new frequency. The dispatcher then would transfer his number to the dispatcher for the new area.

ALLOCATION PATTERNS

THERE REMAINS THE problem of setting up the ten areas and determining how many frequency channels are required. The frequencies used by the base stations in any two areas having a common boundary must be different. The area boundaries are to be drawn in such a way that the number of frequencies required is at a minimum.

This problem is very similar to the classical map problem in topology. The map makers wanted to know how many colors at most were needed to contrast adjacent countries in a mythical continent. The continent was to be of an arbitrary shape and the subdivision into countries was to be performed in any desired manner. The answer is that no more than four colors are ever required, no matter how complicated the map. If the four colors are used properly, no two countries having a common boundary will be shown with the same color.

The solution to this problem tells us that no more than four frequencies are ever needed if we divide the city into areas of any desired size and shape. Perhaps four fre-

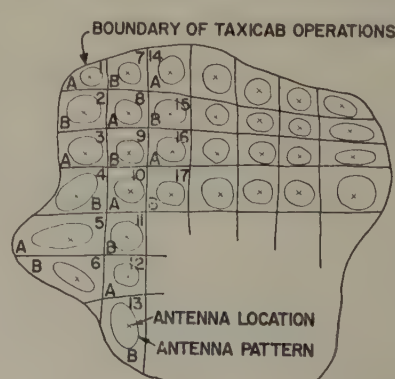

Figure 4. Modified rectangular pattern of space and frequency allocations using two radio-frequency channels, which are lettered

quencies is the answer to very large cities like New York and Chicago if a taxicab operator of a major fleet wishes to provide a radio call service over the entire region. However, in most situations only two or three frequencies are needed if the geometric layout of the areas is properly made. There are two basic patterns employing two frequencies. In one pattern the city is divided into a series of trapezoidal strips with alternate strips using the same frequency, Figure 3. The base stations are located at the approximate center of each strip. The second 2-frequency pattern is the modified rectangular grid of Figure 4. Adjacent boxes use different frequencies. Some interference can be expected in corner regions since the fields must overlap to some extent. Nevertheless, it may be possible sometimes to use this kind of pattern by varying the size and shape of the boxes so that the corners are placed at natural barriers. Figure 4 shows how this can be done.

Where corner interference cannot be tolerated, the 3-frequency pattern of Figure 5 may be used. The basic pattern resembles an arrangement of bricks in a wall but this can be modified as is shown in the figure.

A second 3-frequency method is shown in Figure 6. Here the pattern resembles the spokes of a wheel with alternate sectors being assigned the same frequencies, and the hub assigned the third frequency.

Four basic patterns of areas and frequency allocation have been presented. In designing a radio dispatching system for a specific case, the choice from among the four patterns will be determined by local factors. Some of these are:

1. Street layout and traffic flow pattern.
2. Topography, including hills, cliffs, tall buildings, and open spaces such as rivers and parks.
3. Availability of base-station sites.
4. Number of radio-frequency channels available.
5. Comparative costs.

As an example of the advantages and disadvantages of a particular pattern, consider the radial pattern with the central hub. A centralized location for the base stations and antennas is required. This raises certain technical problems. The distances to be covered along the radii are much greater than the distances in a plan using decentralized base stations. Dead spots and distortion of the sector shapes by reflections from cliffs and tall buildings must be avoided. Care must be taken to minimize the

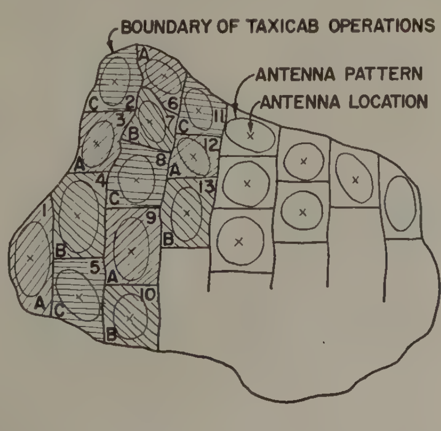

Figure 5. Three-frequency pattern based on rectangular partitioning in which the sectors are numbered and the channels are lettered

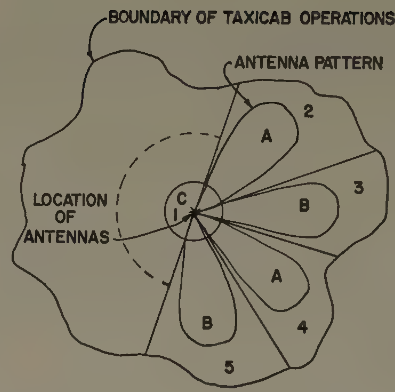

Figure 6. Three-channel system based on sectoral divisions with a circular area at the center which is served by the third channel

directive antenna secondary-lobe interference, which can be expected; see Figure 6. This plan may be very useful in a city that is relatively flat, that does not have many tall structures, and that is built around a central point where a number of important traffic arteries converge. Washington, D. C., is an example.

This plan would be a very poor choice for a large sprawling city composed of a number of distinct and almost self-contained districts. Philadelphia is such a city. The type of pattern illustrated in Figure 5 may be an excellent choice for Philadelphia. This pattern has one distinct advantage in that it permits use of omnidirectional antennas in place of the highly directional type of the radial pattern.

SELECTIVE CALLING

Selective-calling equipment permits a dispatcher to call any one cab, any group of cabs, or all cabs by operating a push-button control board. The call is heard only by the cab or cabs to which it is directed.

Selective-calling equipment is not essential to the operation of the communication system that has been outlined, but its use offers certain distinct advantages. These are summarized briefly:

Elimination of Nuisance Interference. The area and frequency allocations have been set up so that the base station within a given area is always stronger than interfering signals from other areas on the same frequency. In the presence of both signals, the receiver will respond to the stronger one and no appreciable interference will be heard. However, in some places the weaker station may be audible when the strong station is not transmitting. Selective calling would eliminate this nuisance interference as well as all other calls not directed to a particular cab or group of cabs.

Reduction in Driver Fatigue. Without selective calling, a driver must pay constant attention to all dispatched calls. Undoubtedly, this will affect his efficiency and may make him miss a call once in a while.

Increased Passenger Comfort. Some taxicab operators report that passengers often object to the radio chatter and they request the driver to turn off his receiver.

Many taxicab operators objected to the slowness of the old selective-calling equipment. Recently developed equipment puts through a call in less than one-half second. Provision can be made for individual calling, group calling, and general calling.

Overload Protection of A-C Instruments

WILSON PRITCHETT
MEMBER AIEE

ELAZAR TRAU

USUALLY OVERLOADED instruments sustain either mechanical damage or thermal damage or both. The application of a sudden overload develops a torque which accelerates the moving parts of the instrument. Mechanical damage may occur during such acceleration or it may occur during subsequent deceleration when the stop is reached. A slight permanent deformation of one of the parts may spoil the accuracy of the calibration and therefore should be considered as mechanical damage even if no parts are broken.

It has been found that under practical conditions overloads severe enough to cause mechanical damage produce such damage before thermal damage occurs. Investigation shows that except for the electrodynamic ammeter most conventional a-c instruments do not suffer acceleration damage on direct connection to a 240-volt power circuit. All suffer deceleration damage, however, unless the overload is removed within an interval largely determined by the severity of the overload.

The graph of Figure 1 has been computed to show the relationship between the magnitude of the overload torque and its duration which will limit the first throw of the pointer to full-scale deflection. The curves of this graph facilitate determining the operating time required of protective devices intended to prevent deceleration damage. Most conventional instruments require protection after an interval of not much greater than 1 millisecond if deceleration damage is to be avoided.

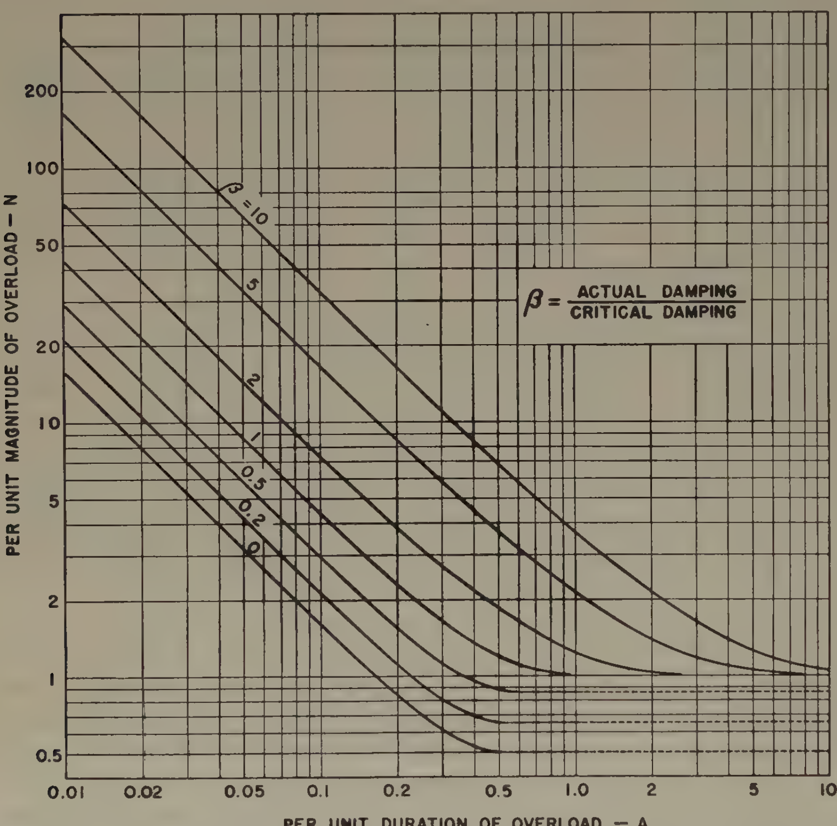

Figure 1. Conditions required to give a maximum throw of full-scale deflection to the moving system of an instrument

$$N = \frac{\text{Actual overload torque}}{\text{Full-scale torque of restoring spring}}$$

$$A = \frac{\text{Duration of overload}}{\text{Undamped natural period of moving system}}$$

β = **Relative damping**

Design features and requirements considered important in instrument protection are:

1. Current circuit protectors should not open-circuit the line in which the instrument is connected.
2. The protective device should be contained within the case of the instrument.
3. The device should not affect the accuracy or usefulness of the instrument.
4. It should protect the instrument from every reasonable overload condition.
5. The protector should be capable of being reset easily and without opening the main seal on the instrument case.
6. It should be impossible to reset the protector against an overload.
7. A conspicuous warning should be visible as soon as the protector has operated.

Protective devices having most of these features have been constructed and tested by the authors. A short-circuiting type current circuit protector, which operates in about 3 milliseconds, has been installed permanently inside the case of a portable wattmeter and has been tested under various overload conditions including direct connection of the current circuit to a 240-volt power circuit while the voltage circuit was energized. The instrument since has given months of service in an undergraduate laboratory.

Digest of paper 52-7, "Overload Protection of A-C Instruments," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Work Simplification

A. H. MOGENSEN

THE TERM "Work Simplification" means many things to many people. To some people it means systems and procedures. To some people it means short-cuts. To some it means the use of gadgets. To me, Work Simplification means this: It is the organized use of common sense to find better and easier ways of doing work. In view of the fact that many people seem to be trying to "expert" Work Simplification, I will change that definition too: Work Simplification is the organized use on the part of everyone involved to find better and easier ways of doing work.

A Work Simplification program aids management in controlling efficiency of operation by stimulating employees to be alert for all possible improvements.

Too many people are not getting the results that they could get from a real Work Simplification program. Work Simplification, in its ultimate sense, is as much a matter of management conditioning as it is of applying recognized techniques.

Psychologists tell us that there are three ways of getting results through people. The first is to tell them, the second is to sell them, and the third is to consult them. Let us look at those three methods for a moment. We are all aware of them, yet very few of us are applying them effectively.

THE FIRST METHOD

IN THE OLD DAYS, management operated entirely on the 'tell 'em' technique. The owner announced a conference and all the men came in, sat around a table, and wondered why the boss was wasting their time when all he was going to do was stand up and tell them what he already had decided to do.

That technique, unfortunately, is still the basis of many conferences. The Army always has been run on that basis. There was some change to the second, or selling, technique during World War II, but recently the New York Times had almost half a page devoted to an article headed "Change Held Vital in Army Study; Survey Shows Necessity for Overhauling Education System of Armed Services."

To determine the attitudes of men in the Army, the writer interviewed 5,000 soldiers. One post commander said smugly that he did not have to explain anything to his men because the good soldier was the one who obeyed without question everything he was told. Another general observed that a soldier needed to be told only two things: where he should be and at what time—nothing else. Thus it can be seen that the Army has not changed much since the days of the Charge of the Light Brigade. It is still operating on the 'tell 'em' technique.

THE SECOND METHOD

SIMILARLY, INDUSTRIAL engineering work over the years has come up through this same technique, and it has not—until recently—been too successful. We have not been selling industrial engineering to management. We most certainly have not been selling it to labor. Many people in industry are making exactly the same mistake. They start out with systems and procedures work entirely on the basis of exploiting. Few firms are combining systems and procedures with an intelligent Work Simplification program, a program involving organized use on the part of all of the people involved to find better and easier ways of doing work. In industrial engineering we recently became aware of the fact that we could not succeed by telling people and so we have begun to do a better job of selling. To install a wage incentive plan or a job evaluation scheme or whatever it is, we now spend time on visual aids and endeavor to develop a presentation.

A few years ago Dow Chemical Company issued a little book[1] entitled "So You Don't Like Time Study—Well Who the Hell Does?" When you get into this book you will find it rather interesting, and maybe some people would find out for the first time what time study really is. Most of those who write books on the subject of time and motion study seem to try and make it just as complicated as they can. Each writer takes the original motion study principles and each adds his own individual theories. We have difficulty in trying to keep some of these things simple.

In many areas we are trying to do a better job by using the selling technique. For example, take the field of economic education. For years the employees were told nothing about the economic position of their companies. It was thought to be none of their business. Today we are doing a much better job of selling people on basic economics because we have come to realize that we are not going to get enthusiastic, wholehearted participation for increasing productivity if the average worker thinks that for every dollar he earns the boss makes three; if he thinks the corporations make far too much in the way of profits; if he has all of the misunderstandings that most people have about basic economics.

The subject of democracy is another example. These are some answers that the New York Times writer got from boys in the service when he asked them for their definition of democracy: "Democracy means getting killed so other

Full text of a conference paper recommended by the AIEE Committee on Management and presented at the AIEE Fall General Meeting, Cleveland, Ohio, October 22–26, 1951.

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countries can get rich . . . Democracy means giving up everything and getting nothing back . . . Democracy means living like a pig for two years . . . Democracy doesn't mean a damn thing to me." And so it's been with an understanding of our economic system. We talk about free enterprise in great glowing terms that most people do not understand. Do not forget that "people fear that which they do not understand." So we're trying to do a better job of selling.

So it is with our methods work. We have finally discovered that telling people that such and such is the way to do a certain job does not work. With skillful selling you may be able to finally get someone to accept your ideas as his own, and for that reason he will get behind that new method or that new procedure and make it work. It takes skillful selling and it is not accomplished often.

THE THIRD METHOD

But the selling technique is not enough. Let us take a look at the third, the consultative approach. In general it is nothing new. There have been books written on multiple management, several on the McCormick Company plan. Some firms now are practicing multiple management. W. B. Given, of American Brake Shoe Company, has written a book[2] called "Bottom-Up Management," again along the same line. Others have talked about consultative management.

To really consult people, you have to be humble. You cannot believe that you have all the ideas, that you know all the answers, that you are the expert. You cannot hoax people by asking them for their ideas. You must be really humble; you have got to believe that your people, your workers, the rank and file people in your offices and plants have better ideas than you have.

People are not fooled very easily. If you run a conference, you must run it on the consultative basis if you are going to get the most from it. At a meeting in Boston recently a young executive said to me, "Well, if you do that aren't people going to lose confidence in you as an executive? If you ask them questions, they may think you don't know very much."

All I can say in answer to a question like that is that those who have tried the consultative method have found that it works, and works better than the other two. It has been shown that those firms which use most of the consultative approach, less of the selling, and very little of the telling are more successful than those firms which use mostly the telling technique.

A GENUINE PROGRAM

A good many people feel that if they train supervision in Work Simplification they have a program. The program has not been completed until you have carried it right straight down the line to every single person in your company. And then, when you think you have completed it, you will discover that it does not stop there: you must continue the program.

I have often been asked how long these programs run. One firm is in its 14th year of the program and it has not stopped getting savings yet. While they make a simple product, they have averaged $500 a year savings per man trained every year for the last 10 years. Too many people think of this type of training as an easy 10-hour course. The trend right now seems to be that we are slipping back into the thinking we had during the war. We must not forget that some of those 10-hour courses were emergency stop-gaps. We suddenly realized that things were very bad and we had to do something about it. Those courses were developed to help firms that had no training whatsoever. I have nothing against any of those courses except that I have not yet found out how to train a supervisor in Work Simplification in less than 30 hours, not to mention the personal consultation that must supplement the classroom training. You cannot do it in 30 hours, and then tell the fellow that he has graduated. You must watch him and see how he puts to work what he has learned, and help him.

From the findings we have made in our work it is clear that a successful program of Work Simplification depends entirely on starting at the very top. There is that conditioning of top management which must be considered. Those companies which are most successful in using Work Simplification are the ones where the top executive group have taken time out (usually three days away from the job), to go through the whole program and find out what it is. They actually make process charts and decide whether or not they want their people to use these tools of Work Simplification.

About the worst thing that can happen when one of these programs is started is what happened in an aircraft plant in Kansas during the war. A lead man was instructing a new girl on a riveting job and his instructor came up to see how his man was doing. The young man was doing a fine job until his general foreman came up to him and asked, "What do you think you're doing here?" The younger man said, "I'm teaching this girl her job." "Never mind that bunk," said the foreman. "Get back on the line and don't waste your time on that stuff."

Try to realize just exactly what that meant to this man. I do not care how good the course was, I do not care how good the instructor was. The next time the man went to class—if he did go to class after that—he would sit there looking at his instructor and think, "Yes, but my boss, the one who keeps me on the job and pays me, said this was a lot of bunk." No program would be of any value from then on. It would be a complete waste of time.

There is too much of that. We get the supervisors interested in using some of the tools of Work Simplification, they start to make up flow process chart studies—and what happens? The boss comes in and says, "Throw that stuff away. We haven't got time for it. Get out there and get your job done." You have to start at the top and your very top management has to believe in the consultative approach. They must believe in the philosophy of the program.

NEGATIVE REACTIONS

Resistance to Change and to New Ideas. People resist change. They resist new ideas. If you do not believe me, try this experiment with your dog at home. If your

dog is sitting in front of the fire minding his own business some night, come up behind him quickly and give him a push and see what will happen (do not try it with somebody else's dog—I do not want you to get bitten). I'll tell you what will happen; your dog will dig in. The minute you push, your dog will resist and if he is on a rug he will actually pull the rug in his effort to resist. Well, you say, maybe he is afraid of the fire. All right then, start pushing him from the other side quickly. All he does is reverse his brakes. The harder you push, the harder he digs in. But if you get your hat and go out for a walk, he probably will be running right along with you. Did any thinking go into that? Was any decision made on the part of the dog? No, it was an instinctive, automatic reaction. People react to new ideas in the same way. When an expert rushes in with new ideas, he is going to be resisted just as surely as when you try to push the dog quickly.

It takes considerable skill to sell your ideas. Everyone resists change. Perhaps we all realize these things, yet every time we try to make a sudden change in our methods we violate these two fundamental points in human nature. The answer to the problem is a simple one. Jimmy Durante is always complaining that "everyone's tryin' to get into the act." My comment to that is let them get into the act. A real program of Work Simplification is merely getting everyone into the act. Make it everyone's program and you will find that you will get the response you need and the results you want.

Resentment of Criticism. This point is also important because whenever you criticize a method, someone takes it as personal criticism. Do not forget that. I went through one of the large automobile plants some years ago with the chief engineer and he was criticizing himself for some of their methods. He was pointing out to me how much they needed a Work Simplification program. He walked up behind two girls who were putting grease on the mechanism that raises and lowers the windows in the car door. The girls had a great mound of grease and a paddle and as the assembly came down the line, they slapped some grease on it in a couple of places. There was grease all over the floor, and there was grease all over the girls. Everything was a mess. As we walked up behind the two girls he said, "Now this is a terrible operation, one of the worst in the plant. We've certainly got to do something about it." As we walked away, I watched the girls because sure as could be, one of them looked up from her work and said to the other, "Who does the so-and-so think he is!" And you would react in exactly the same way if someone walked up behind you on your job and made that comment. Is there any wonder people resist change when we notice the way in which changes are presented?

THE WORKER'S IDEA

The thing to remember is that you should let the change be the worker's idea. If you can overcome these two obstacles—resistance to change and resentment of criticism—you will be surprised to find that your Work Simplification program will have the full support of your workers. Begin your conditioning job at the top, but carry it right down to the bottom. Let everyone into the act. Let your engineers be consultants on call, but do not let them be experts.

So to sum up, let us say that Work Simplification can simplify the complex science of efficiency of operation to such a degree that every individual can understand at least that part which applies to his own work. We propose that every employee be made capable of and responsible for policing the efficiency of his own job. Therefore management must provide the employee with the training, and the tools and techniques, required to make him capable and responsible.

Work Simplification is a field, a way of thinking, a philosophy, not a packaged scheme. Neither is it a "sure-shot" method. But it can work and it has worked, and to insure success it requires the application of these principles:

1. The ability and initiative of the individual is a great potential asset.
2. Through training, management must make this asset effective for cost reduction and betterment of business.
3. The individual can be induced to utilize his trained ability by providing appealing incentives, and the incentives need not be cash.
4. Channels of communication must be properly established to assure the ideas are measured impartially and correctly, and quickly installed when sound.

The philosophy of Work Simplification, therefore, is simply that difficult problems can be reduced to simple steps, and that management can control efficiency of operation by stimulating employees to be constantly alert for possible improvements.

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New Low/Medium-Frequency Transmitter

A new type *MW* low/medium-frequency transmitter is available from the Westinghouse Electric Corporation for fixed station operation. The design of this equipment represents a new approach to the problem encountered in using large inductors and capacitors at the low frequencies. The conventional tank-type circuit, at these frequencies and at this power, requires components that are large. Also multifrequency selection and operation when using conventional components requires the use of relays, motors, or manual switches. The type *MW* transmitter uses iron-core transformers at the low and medium frequencies. These units are small in size and eliminate the necessity for tank-circuit tuning. The unit is designed for operation over an ambient temperature range of from 0–50 degrees centigrade and for values of relative humidity up to 95 per cent.

Current Asymmetry Effects in Circuit Interruption

W. F. SKEATS
FELLOW AIEE

IN AN A-C CIRCUIT containing a substantial amount of inductance in proportion to its resistance, the current which flows immediately after the circuit is closed may be asymmetrical. Asymmetry arises from the fact that the current through an inductance cannot change in zero time from zero to any substantial value as would be required in most cases if the current were to assume its steady-state value immediately after closure of the circuit.

Asymmetry is probably the source of more difficulty in the application of circuit breakers than any other one item. According to the American standards, an asymmetrical current is evaluated according to the rms value of both a-c and d-c components in combination. According to European standards, the current is evaluated for rating purposes according to the a-c component only. Thus, a circuit which might have an a-c component of current equal to 14,000 amperes combined with a d-c component of 10,000 amperes would require for its interruption a circuit breaker rated 14,000 amperes according to European standards, but a circuit breaker rated 17,000 amperes according to American standards. On currents sufficiently asymmetrical, therefore, a circuit breaker rated 14,000 amperes by European standards will interrupt as much current as one rated 17,000 amperes by American standards. But a symmetrical current of 17,000 amperes requires a circuit breaker rated 17,000 amperes according to either standard.

With both types of current the actual severity varies over a wider range from one operation to another purely as a result of variations in the point on the current wave at which the contacts are separated than is caused by the difference in severity of the two types. The effect of asymmetry on severity does not appear to be the same for all types of circuit breakers.

There are four aspects of asymmetry which may influence the severity of a circuit interruption. These are: 1. the average and the rms values of current are increased; 2. the time interval between current zeros is uneven, being alternately longer and shorter than the uniform values applying to symmetrical waves; 3. the rate of change of current as it approaches current zero is less; 4. the magnitude and rate of rise of the recovery voltage transient are, in general, less.

It may be judged that the first of these effects would tend to increase the severity of interrupting duty, the second may at times increase it and at times decrease it, while the third and fourth may be expected to decrease the severity of duty. It may be expected, therefore, that the net effect will vary from circuit breaker to circuit breaker and possibly from test to test on the same circuit breaker according to the relative effect of these four aspects. In this case, the various types of interrupting devices should be considered separately.

In a comparison of the performance between oil and air-blast circuit breakers, it is found that the severity of duty on an oil circuit breaker is increased by the presence of a d-c component and may best be represented by the total rms current, whereas the severity of duty on an air-blast circuit breaker is unaffected by the presence of any d-c component. It is interesting to investigate the effect of rating structure on these two types of circuit breakers. If it is desired to meet a given kilovolt-ampere rating on an rms total basis, an oil circuit breaker which will meet this condition at any one condition of offset will be close to meeting it at any other condition of offset and will have its interrupting ability fully utilized. With an air-blast circuit breaker, the rms total interrupting capacity is much greater on a displaced wave than on a symmetrical wave so that to meet its rating on a symmetrical basis it must have a substantial excess on an asymmetrical basis, and this excess cannot be utilized.

If rating is on an a-c component basis, however, the air-blast circuit breaker meets the rating equally well at all values of offset and so will have its interrupting ability fully utilized whereas the oil circuit breaker must provide excess unutilized interrupting capacity under symmetrical conditions to meet its interrupting capacity under asymmetrical conditions.

CONCLUSIONS

1. In addition to such changes in severity of interrupting duty as are attributable to current magnitude and displacement or to voltage magnitude and recovery rate, very wide changes may be introduced purely as a result of variation in the point of the current wave at which the contacts separate.

2. If this point is left to vary at random, many tests may be needed to ensure that the worst conditions have been encountered. A considerable reduction in the required number of tests may result from control of timing through synchronous closing and synchronous tripping.

3. Synchronous closing is available in the testing laboratory for simple opening tests through the use of a suitable closing switch. It is not available on closing-opening tests except in the infrequent cases where the closing time of the test circuit breaker is consistent within about 1 millisecond.

4. For oil circuit breakers, if tests are controlled effectively for worst timing conditions, the use of asymmetrical currents for testing results in test interrupting duty at least as severe as the interrupting duty on a symmetrical current of the same rms value.

Digest of paper 52-28, "The Effect of Current Asymmetry on Circuit Interruption," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Patents in History

W. J. BLENKO

"What is an Invention" and "Who is the Inventor?" The author defines these terms and lists the requirements for a valid patent under our statutes.

IN THIS ARTICLE the history of the patent system both in England, where it originated, and in this country, will be traced briefly. I shall try to relate it to some of the events of history, to appraise it as of today, and to venture some opinions as to its future.

HISTORICAL BACKGROUND: ENGLAND

THE PATENT SYSTEM reaches back for centuries. It originated in England where the early kings held that as a matter of royal prerogative they could grant monopolies at will to their subjects. These grants were not sealed up or addressed to any one person or persons but were by royal letters addressed to the realm at large and, hence, were called "letters patent." The first grant of which any record survives was by Edward III in the Fourteenth Century. The practice was continued by succeeding kings but it was not until the reign of Henry VIII (1509–1547) that it was given its real impetus.

Henry was born in 1491 and was crowned in 1509. In that period Columbus had discovered America and the Cabots, under the shield of Henry VII, had made their voyages to the northern shores of this continent. Henry VIII was perhaps the first big Navy man. He envisaged England as a great power, but, most significantly, he thought in terms of commerce and not simply in the traditional terms of military or political domination. Perhaps more than any other man, he turned England in the direction of a manufacturing and exporting nation. Henry wanted to encourage the growth of new industry, and to that end he granted patents on a large scale to inventors or to people who brought new inventions from abroad and introduced them into the realm.

The philosophy was the same then as it is now, namely, that the granting of an exclusive right in the manufacture and sale of a new thing, for a limited period of time, encourages and contributes to the growth of the country's industry and commerce.

The system appears to have worked well, but in the reign of Elizabeth (1558–1603) abuses crept in. She granted monopolies not only to new inventions but to industries already established. The difference between the two situations is plain: the granting of an exclusive right in a new thing takes nothing away from the public; the granting of a monopoly in a thing already known and in use does take something away. Late in her reign, in 1602, the right of the sovereign to grant monopolies in things already known came to a judicial test. Elizabeth had granted a monopoly for making playing cards and the validity of the grant came before the English courts in the case of *Darcy versus Allein.* It must have been a rather dangerous thing to be an independent judge in those days, but the court held, most diplomatically, that the grant was restrictive of trade, that the Crown had been imposed upon, because it would not wittingly have granted any monopoly that was injurious to the state, and that it was therefore void.

Perhaps kings, too, had their troubles in resisting the pleas of those who were close to them. At any rate, in 1610, King James I, who had succeeded Elizabeth in 1603, made what was called a "Declaration of Bounty" in which he forbade anyone to move him for a monopoly except where there was special merit to be rewarded.

But that did not end the abuses, and in 1623 Parliament stepped in. It enacted the "Statute of Monopolies" which declared that letters of monopoly that are "grevious and inconvenient" to the subjects of the realm are void. But, because it found them to be in the public interest, Parliament made an exception of letters patent for the "sole working or making of any manner of new manufacture which others at the time of making such letters patent and grants should not use, so they be not contrary to law, nor mischievous to the state by raising of the price of commodities at home or limit of trade or generally inconvenient."

Thus we see that the patent system reaches back for more than a century before Columbus and that it operated on formal grounds, as distinguished from being a matter of merely kingly pleasure, for more than 150 years before the American Revolution.

HISTORICAL BACKGROUND: AMERICA

IT IS INTERESTING to note here that one of the causes of the Revolution was the British policy of rigidly limiting the growth of manufacturing industry in the colonies, seeking to maintain them as agrarian communities supplying raw materials and taking English manufactures in exchange; one of the grievances stated against George III in our Declaration of Independence was his act in "cutting off our trade with all parts of the world." It is perhaps indicative of the state of affairs in this country that there appears to be only one manufacturer, George Taylor of Pennsylvania, a maker of iron, numbered among the signers of the Declaration.

The loose confederation which existed after the Revolution was replaced by our present frame of government

Full text of an address presented before a meeting of the AIEE Pittsburgh Section, October 9, 1951.

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when the Constitution was adopted and ratified. Among the many fundamental decisions expressed in that instrument was the one that we should have a patent system. Its basis is in Article I, Section 8 of the Constitution, which reads: "The Congress shall have power . . . to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

It is clear from the constitutional provision that its framers were moved by the same considerations that had motivated the English Parliament when it enacted the Statute of Monopolies. The fundamental principle is that the public interest is paramount and the fundamental philosophy is that that interest is subserved by the grant of exclusive rights, for limited times, in new things.

Our first patent statute was enacted by Congress in 1790. Under it the granting of patents was entrusted to the Secretary of State, the Secretary of War, and the Attorney General, or any two of them. This scheme ultimately became unwieldy and there was a general revision of the patent laws in 1836.

The law of 1836 contained most of the provisions which are basic to our patent laws as they exist today: it created a Patent Office; it provided for an examination of applications for the purpose of ascertaining whether the subject matter was patentable; it provided that the patentee should distinctly claim that part of his disclosure which he asserted to be his invention. All of these requirements are readily recognizable in our patents today.

A word as to "specification" and "claims" may be in order here: A patent may be thought of as a contract whereby, in exchange for the disclosure of an invention in such terms that any interested member of the public can make and use it, the patentee is granted a right to exclude others from the enjoyment of the invention for a limited period, after which it becomes public property forever. The purpose of the specification and drawings is to disclose the invention in such terms that it may be understood and practiced when the patent expires.

The requirements for a claim or claims is strictly an American invention. In the early days in England when the king granted a patent, the invention was designated by title but was not further specified at all. The patentee might allege, and in many cases seemingly did allege, that anything that fell within that designation was covered by the patent. Early in the Eighteenth Century the practice was inaugurated of requiring the grantee to file within six months *after* the grant of his patent a description of his invention and the manner in which it was to be performed. It was not until 1852 that a patentee in England was obliged to file a description with his application.

The requirement of our 1836 statute, that the patentee must separately claim his invention, was apparently in recognition of the growth of the useful arts. By that time it had apparently become obvious that in describing something new the applicant almost inevitably had to describe a good deal that was already old and the law cast upon him the burden of distinguishing. The patent claim is now a feature of the patent law of most countries—France is a notable exception—and is the measure of the grant.

In 1837 our population was about 15,000,000 people. Our western frontier was east of the Rocky Mountains. It was soon extended westwardly by two inventions—Colt's revolver and barbed wire. At that time the cotton gin was more than 40 years old but the telegraph, the phosphorus match, and the screw propeller had just been invented. The sewing machine was still 10 years in the future and the age of steel, beginning with the process independently invented by Bessemer and Kelly, was still two decades away. That latter process, after the discovery by Mushet of the advantage of a manganese addition to the molten metal, was destined to be the basis of Pittsburgh's greatness as the steel center of the world, under the guidance of an ex-telegraph operator for the Pennsylvania Railroad, Andrew Carnegie.

In 1837 a record number of patents was issued, 435 in all.

The period 1837–1860 was a most fruitful one inventionwise. To mention but a few, it saw the birth of electroplating (1838), the vulcanization of rubber (1839), photography (1839), the telegraph (1844), Portland cement (1845), the pneumatic tire (1845), the sewing machine (1846), and analine dyes (1856), not to mention the safety pin (1849) and the paper collar (1854).

I often have wondered what would have resulted if some ingenious person had invented air conditioning in that period. It is quite possible that there would have been no Civil War. We know that the cotton mills settled in New England for the same reason that they concentrated in Manchester in England, namely, that the weather was suitable for the spinning of cotton thread. The result was that the South was in agrarian bondage to a manufacturing North just as the colonies before the Revolution were in agrarian bondage to a manufacturing England. The issue of slavery was in large measure an economic one and I do not doubt that if the spindles had moved south early in the Nineteenth Century, as they were destined to do when man controlled the weather, the economics of the North and the South would have been wholly different.

In the field of electricity we naturally begin with the discoveries of Michael Faraday (1791–1867). His work on induced currents, which lies at the base of the whole science, was foreshadowed in a letter to a friend in September, 1831, in which he said: "I am busy just now again on electromagnetism, and think I have got hold of a good thing, but can't say. It may be a weed instead of a fish that, after all my labour, I may at last pull up." After he had done his work, however, he had no doubts. He is reported to have met the inquiry of a politician, "What good is it?" with the reply, "Some day you will tax it."

The great onrush of electrical inventions and the resulting transformation of our world, especially in the fields of transportation and communication, is relatively more recent and better known to most of us, and I shall not dwell upon it, beyond venturing the statement that the greatest possibilities for future innovation seem to lie in the fields of electricity and chemistry. Nor do I see any terminal point. In the depression years of the 1930's it was said that we had reached our economic frontiers, but we know enough now to know that we know very little.

PATENT REQUIREMENTS

So much for history. I propose to turn now to other phases of the patent system and shall begin with a brief mention of the requirements for a valid patent under our statutes.

All federal law under our system of government stems from acts of Congress under the Constitution and the requirements for a patent are found in the statutes. Passing the matter of plant patents, a relatively recent innovation, the pertinent requirements for a patent are as follows:

(1) It must be for an invention or discovery. I shall have more to say about that in a moment.

(2) It must relate to a new and useful art, machine, manufacture, or composition of matter or a new and useful improvement thereof.

This provision rules out a number of things which might qualify as inventions in the broad sense. Thus the discovery of anaesthesia in surgical operations was held not to be within the area in which Congress had provided patents might be granted.

(3) It must not have been known or used in this country before the invention was made by the applicant for the patent.

Under this provision, prior knowledge of invention in a foreign country and not transmitted to the United States is not a bar but if A makes the invention in this country ahead of B then, whether A patents it or not, B cannot have a valid patent on it.

(4) It must not have been patented or described in any printed publication in this or any foreign country before the applicant's invention or discovery.

This provision makes a foreign patent or publication a bar although knowledge or use in a foreign country is not a bar. The reason is that a printed publication or a foreign patent may be expected to reach this country and to disclose the invention to the public here whereas mere local knowledge or use in a foreign country, not evidenced in a printed patent or publication, is not likely to become known here.

(5) It must not have been patented or described in any printed publication in this or any foreign country more than 1 year prior to the filing of the application for patent.

Under this provision it makes no difference what the date of actual invention may be; time begins to run against the inventor after his invention is described in a printed publication even though he may know nothing of the publication and may have had nothing to do with bringing it about. He must still get on file within 1 year of its date.

(6) The invention must not have been in public use or on sale in this country for more than 1 year prior to the application.

This requirement, like the preceding one, is absolute. A single day over the period allowed by statute is fatal. *Bona fide* experimentation, even in a public place, is not a "public" use within the meaning of the statute, but a single use for profit, not intentionally concealed, is within its terms.

(7) The invention must not have been abandoned by the inventor. In short, a man may make an invention but if he sets it aside he cannot come along years later and assert a right to patent it.

WHAT IS AN INVENTION?

The question always arises, "What is invention?" No wholly satisfactory definition has been formulated and I doubt if one ever will be. Judge Learned Hand has said, "An invention is a new display of ingenuity beyond the compass of the routineer, and in the end that is all that can be said about it." It has repeatedly been said that it must be something more than an exercise of the expected skill of a man acquainted with the business. To my mind the essential thought has never been better expressed than by William James in his definition of genius, which, he says, is "but little more than the ability to perceive in an unhabitual way."

The difficulty lies in applying the rule to particular cases. It is obvious that we cannot proceed *in vacuo* but must look at the putative invention in the light of all that has gone before, and that presents difficulties because it requires us to say, with the solution to the problem laid before us, whether that solution was obvious when only the problem was set out. History is often a guide: if there has been a long-felt want, and many unavailing attempts to satisfy it, the final step which does satisfy the want may generally be regarded as inventive. Contrariwise, if several independent workers promptly arrive at the same solution to a problem newly arisen, it is rather strong evidence that the solution was within the expected skill of the men acquainted with the business.

WHO IS THE INVENTOR?

Under our patent statutes the patent must be in the name of the true inventor. This does not mean that he cannot assign it in whole or in part. It does mean that if the wrong person is named as the inventor the patent is invalid. All of the other requirements for a patent may have been met but an error on this point is fatal.

Questions of inventorship frequently arise, notably in places like research laboratories where a number of people have been engaged on the same project.

Where the work of more than one man is involved, the invention may be sole or joint. There is a natural tendency to join all of the leading workers on the problem as joint inventors, sometimes because the applicable principles are not well understood and sometimes because questions of personal pride in achievement are involved and there may be a substantial loss of interest or further co-operation on the part of one or more of the individuals concerned unless the issue is settled in a way that seems fair to them.

To answer the question "Who is the true inventor?" we must sort out the contributions of the various people involved. The test was stated long ago by the Supreme Court in the following terms: "...where a person has discovered an improved principle in a machine, manufacture, or composition of matter, and employs other persons to assist him in carrying out that principle, and they, in the course of experiments arising from that employment, make valuable discoveries ancillary to the plan and

preconceived design of the employer, such suggested improvements are in general to be regarded as the property of the party who discovered the original improved principle, and may be embodied in his patent as a part of his invention....

"Persons employed, as much as employers, are entitled to their own independent inventions, but where the employer has conceived the plan of an invention and is engaged in experiments to perfect it, no suggestions from an employee, not amounting to a new method or arrangement, which, in itself is a complete invention, is sufficient to deprive the employer of the exclusive property in the perfected improvement. But where the suggestions go to make up a complete and perfect machine, embracing the substance of all that is embodied in the patent subsequently issued to the party to whom the suggestions were made, the patent is invalid, because the real invention or discovery belonged to another."[1]

Thus, if A plans a line of inquiry and B carried out the work, B is merely the "hands" of A, and the title of inventor properly belongs to A. This, of course, is an extremely simplified case, but it generally will be found on analysis that the rule which I have quoted can be applied without too much difficulty.

The second question, that of joint invention, offers many pitfalls for the unwary. I have seen many good cases wrecked because someone made a bad decision on the question of inventorship. The patent must be in the name of the true inventor or inventors and no one else if it is to be valid. Thus if A is the sole inventor, a joint patent to A and B is void. Similarly, if A and B are the joint inventors, a patent to either of them, unjoined with the other, is void.

There is a natural, and for that reason a very dangerous, tendency to join various workers in a patent application simply because all of the supposed joint inventors have worked upon the problem, and without any critical analysis of their respective contributions. But mere participation does not make for joint invention. There is joint invention only where two or more persons, acting jointly, conceive the same idea of means, or of formula, or of process. There must be a unitary idea which is the product of two or more minds working in communication with each other. Perhaps another way of stating it is that it is generally impossible for truly joint inventors to segregate their contributions to the single inventive concept. Here again it is essential to analyze the development and to find out whose was the head and whose were the hands, bearing in mind, of course, the previous rule, already stated, that suggestions toward the end already conceived and which do not alter the essential concept do not constitute separate inventions and do not require the inclusion of the suggester as a joint inventor.

PATENTS AS PERSONAL PROPERTY

PATENT RIGHTS are a species of personal property and, as is generally known, may be sold or licensed. It is a relatively common practice for employees to contract with their employers at the beginning of a term of employment to assign any inventions which they may make in the field of the employer's business. In the absence of such agreements questions of varying degrees of difficulty may arise. Generally speaking, if a man is employed for the purpose of making new developments, any inventions which may come out of his work are and should be the property of the employer for in making the invention the employee is merely doing what he was hired to do. If, on the other hand, his work involves no substantial element of expected development, any invention which he may make does not vest in the employer. If he has used the employer's time, facilities, or materials, an implied license called a shop right may arise but subject only to this the invention remains and should remain the property of the employee. The implied license arises because the law assumes that the employee would not have used the employer's time, facilities, and materials except for the benefit of the employer.

In the absence of an agreement to the contrary, joint inventors have equal rights in the patent.

A common mistake concerning jointly owned patents is the assumption that the several co-owners are required to account to one another for any proceeds they may make out of the invention. Actually there is no such obligation in the absence of an agreement. Lacking such an agreement, each of the owners can exploit the invention and retain the proceeds for himself. In this respect even a trivial interest in the patent may be of the utmost value to the holder and of the utmost embarrassment to the majority owner.

Licenses may be exclusive or nonexclusive and may be on a wide variety of terms. A doctrine which has arisen over the past 20 years, however, frowns upon license agreements which are conditioned upon the purchase of unpatented equipment from a source designated by the licensor. A striking example is found in the so-called *Mercoid* case.[2] It involved a patent for a heating system. The crux of the development lay in the thermostat which was a specialty device but which was itself unpatented. The patent was exploited by the granting of licenses upon the purchase of the thermostats to be used in the installation but no licenses were otherwise granted. It was held that this constituted an attempt to create a monopoly in the unpatented thermostats and that the patent would not be enforced so long as the owner continued to do business in this fashion.

During the 1930's there was a good deal of talk about "technocracy." There were suggestions to the effect that our patent system had been a good thing in its day but that the day was drawing rapidly to a close. We have heard very little about it since the public advent of nuclear fission. I think, therefore, the system is likely to continue indefinitely without any fundamental change. There is a growing integration of patent law and antitrust law and some anomalies may be discerned. I believe, however, that we shall not depart materially from the philosophy of the Statute of Monopolies enacted in 1623.

REFERENCES

1. Agawam Company versus Jordan. United States Reports, volume 74, 1868, page 602.

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Signal and Supervision Circuits for Carrier-Current Communications

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Carrier-current equipment has become an important adjunct to the operation of large power systems. This article describes some signaling and supervisory trunking systems and illustrates how they are applied to carrier-current transmission.

THE PAST FEW YEARS have shown a tremendous growth in the use of carrier-current equipment to solve a multitude of problems encountered in the operation, construction, and control of power utility equipment.

In many cases the increased use of carrier-current equipment has come about as an economic expedient, with an eye toward more complete utilization of existing plant facilities, as well as increasing the ease and efficiency of supervising, operating, and maintaining the modern network of transmission lines, plants, and equipment that make up a complete power system.

In a power system incorporating over 70 electric generating plants, 20 or more gas compressor stations, and the attendant network of transmission lines consisting of electric conductors and gas and water pipe lines, covering in area some two-thirds of the State of California, it is of some importance to utilize not only the voice communications and telemetering advantages of carrier-current systems but also to give some thought to the supervisory methods that will most efficiently furnish the greatest factor of utilization of these communication channels.

The carrier-current communication system used by the Pacific Gas and Electric Company makes use of special types of supervisory, ringing, and signaling combinations. The network is made up of two general types of carrier-current transmission mediums. The first includes the power-line carriers, consisting of telephone transmission channels and alarm and supervisory carrier units, all utilizing the power line conductors as a means of establishing various communications channels. The second type includes the telephone-line carrier circuits consisting of voice, signal, alarm, and control circuits superimposed on the telephone wires which make up the vast network of the company's telephone system.

These telephone wires vary considerably from commercial telephone lines by the very nature of the duty they perform and their strict co-ordination with the electric transmission system. The matter of inductive co-ordination for the reduction of noise and the protection of personnel and equipment and matters of protection and co-ordination have in themselves become complex studies.

The power-line carriers as a group vary as to the system of emission of energy conveying intelligence and the signaling systems used in the supervision of communications where circuits are terminated on various plant-telephone switchboards. For the greater part the emission system used is amplitude-modulated single-channel transmission utilizing 2-frequency transmission between terminals. These units vary in power output from 5 watts to approximately 50 watts and are coupled to the power transmission lines through impedance-matching radio-frequency networks, capacitive couplers, and drainage coils in the conventional manner.

The transmission lines are trapped at most stations to reduce attenuation of the transmitted radio-frequency energy. Traps are installed to reduce losses in the station bus network, circuit breakers, transformer banks, and associated equipment. Radio-frequency traps and coaxial by-pass systems generally are provided through intervening transmission substations. In the system under discussion here frequency-modulated and single-side-band terminals are used also in the same frequency ranges but somewhat less generally than amplitude-modulated equipment.

RINGING AND SIGNALING SYSTEMS

THE RINGING and signal systems of these power-line carrier circuits, as a whole, are probably somewhat different than in other power utility applications.

Figure 1 shows diagrammatically the general arrangement of a typical power-line carrier-current terminal with its output and input systems matched to an audio-frequency hybrid system and then coupled to a signal supervision system and terminated on a jack position of the plant's cord-type telephone switchboard.

Figure 1 also shows the arrangement for coupling the same carrier-current terminal alternately to a key-type telephone switchboard, commonly used in some plant installations where the necessity for more than three simultaneous conversations originating from the station are not probable.

Other than the channel capacity difference inherent in these key-type switchboards and the fact that they require the use of line-lamp supervision on their common-battery local circuits within the plant, they are equipped

Full text of paper 51-188, "Signal and Supervision Systems Used on Carrier Current Communications Circuits," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Published in AIEE *Transactions*, volume 70, part I, 1951, pages 990–4.

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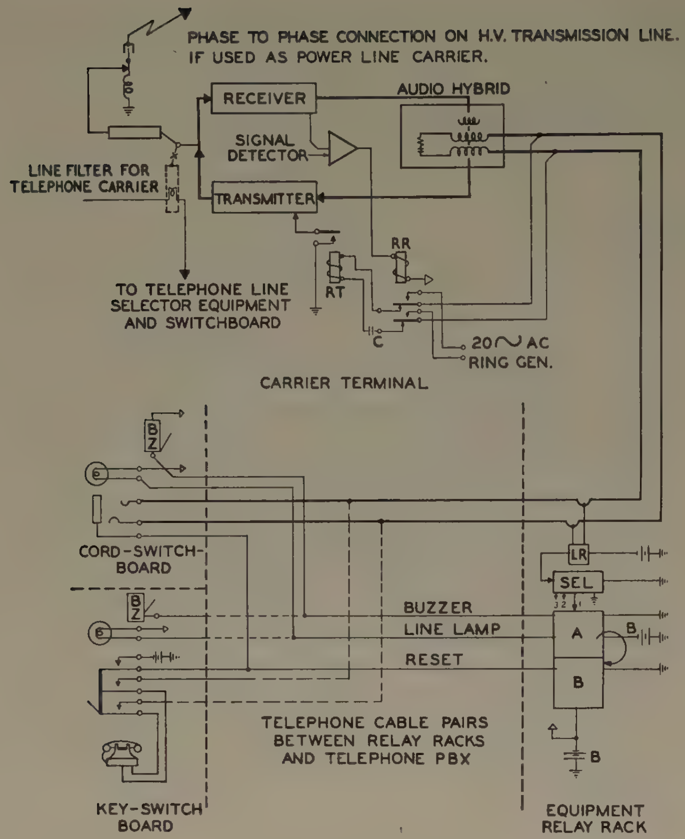

Figure 1. Typical power-line and telephone-line carrier supervision equipment

to furnish the following supervisory features: line-lamp indication of an incoming signal from the carrier terminal; and line-busy signals to additional switchboards that might be operated in multiple with the main key-switchboard unit. These switchboards are not required to supply the operator with disconnect "cord-light" supervision as do the majority of the cord type switchboards used in the larger installations.

Figure 1 also indicates the system used in terminating the greater number of telephone-line carrier-current terminals, and illustrates diagrammatically the low- and high-pass filter assembly which is inserted in the physical telephone line to utilize the frequencies between 4 and 40 kc for carrier-frequency communication on the company's telephone lines.

Referring again to Figure 1 it is seen that the distant transmitter would transmit energy in its carrier band to the illustrated terminal for ringing or signaling, and also that the signal detector of this receiving terminal would be operated, and in turn operate, a relay in its plate circuit, called a "ring-in relay."

The function of this relay is to open the "drop" toward the receive carrier terminal, and to apply the drop's tip and ring legs across a local source of 20-cycle ringing power. It appears at this point that the ring-in relay in the signal demodulator's plate circuit might easily apply a d-c potential to a separate circuit to operate a selection device, but the use of 20-cycle ringing power allows some degree of standardization in the switchboard and supervision selector equipment where it is desired to have like supervision and operation of metallic-magneto and carrier circuits on the same switchboard installation.

Figure 1 indicates that the line-relay (*LR*) is bridging the drop from the carrier terminal's audio output to the the plug-jack on the switchboard. This line relay is shown in Figure 2 mounted above the relay type code selector generally associated with it. The line relay is a sensitive unit designed originally for signal use with magneto party telephone lines, and normally will operate over wide limits of 20-cycle voltage, from approximately 12 to 90 volts, and still offer a high impedance to the audio-frequencies appearing on the drop from the carrier terminal's output.

This line relay must respond to coded rings consisting of a sequence of long pulses of $3^1/_2$ seconds and short pulses of 1 second, with a maximum of 3-second spaces and a minimum of 1-second spaces. This system of coded ringing stemmed from the operation of long magneto party lines, where it was desired to ring-in the station code selector from another station as well as to have a selector that could be operated by patrolmen and others using portable telephones with hand magneto-crank ringers.

The code selector systems used in conjunction with the line relays also are shown. Figure 2 illustrates the typical construction of one of the relay type selectors and its associated line-relay in a rack-mounted assembly. The relay type selector consists of three slow-release slugged telephone relays, one slow-operate relay, a pendulum time delay relay, and a magnetically operated minor switch, equipped with two 10-digit banks.

These selector relays are assembled on a base of formed sheet iron, and arranged to be jack-mounted on a vertical rack. The strapping on the rack side of the mounting-jack determines which one of 11 possible codes the selector

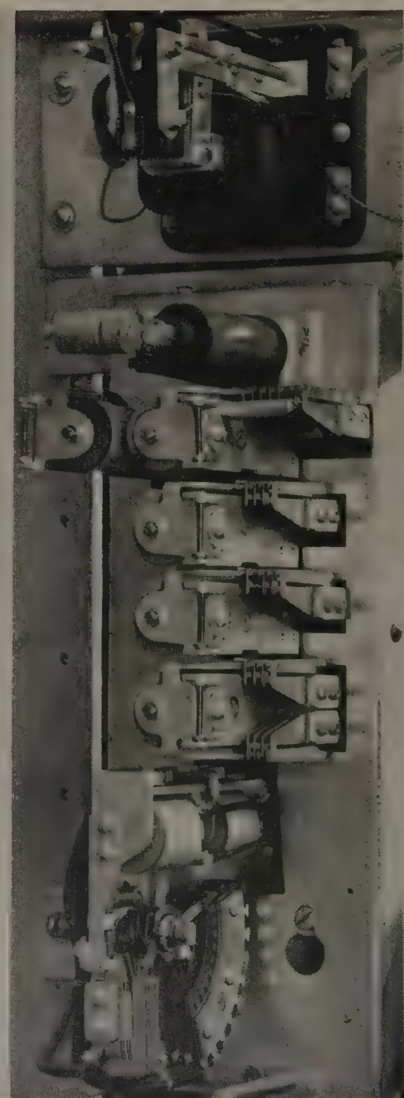

Figure 2. Relay type telephone selector and associated line relay

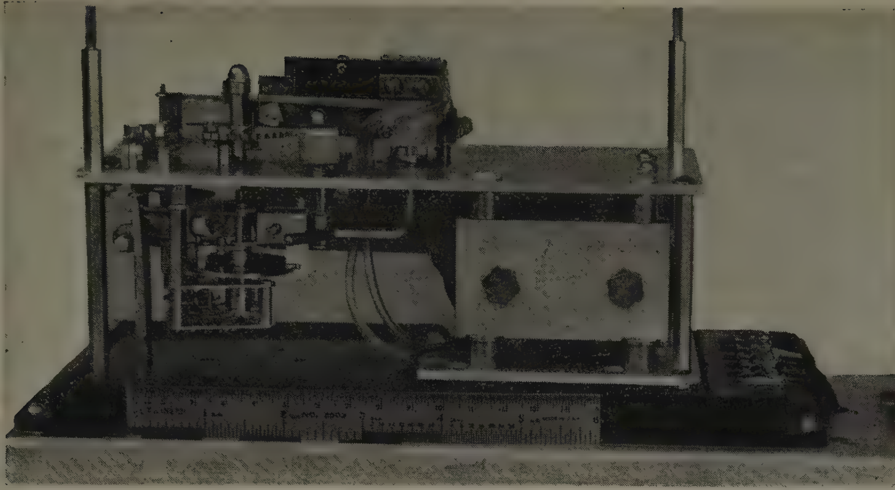

Figure 3. A mechanical type telephone selector

will respond to, with each station in the system having an assigned code.

This arrangement of jack-strapping allows any code selector unit to be changed from one station to another without any internal adjustments. Installation in a remote station jack-mounting will establish the proper wiring to the selector and order its response to the proper code.

Improperly coded signals, or signals intended for other stations along a "breakout" carrier installation, are received and followed by the line relay, but any variation in sequence from the proper code will cause the selector to fail and its stepper-switch to lock, for $3^1/_2$ seconds after the last pulse of the code, at which time the selector resets automatically under the control of its pendulum time delay relay and is again ready to respond to any operation of the line relay.

Operation of the selector by its assigned code-sequence causes operation of its line-lamp relay, indicated in Figure 1 as relay *A*. This relay locks over its own contacts, and holds battery potential on the switchboard line-lamp associated with the circuit. Insertion of a plug or operation of a line key to the signaling line operates relay *B*, which in the case of the relay type selector also is mounted on the same base assembly. Relay *B* energizes the counter coil of relay *A*, extinguishing the line-lamp.

The *A*, *B* relay combination is so designed to give complete "ring back" or "rering" supervision; that is, with a cord plug inserted in the switchboard and the line-lamp extinguished, should the party at the remote carrier terminal again desire to summon the operator, another coded ring would cause the selector to operate again and, by differential control of the *B* relay, to lock again the *A* relay in its operated position, lighting the switchboard line-lamp, which then can be reset or extinguished by a quick removal and reinsertion of the switchboard plug.

The mechanical type code selector illustrated in Figure 3 is designed to respond to the same type of codes as the relay type selector described. This mechanical selector offers a 300 per cent greater combination of codes and somewhat greater ease of field adjustment and maintenance.

The system requires that in using the mechanical selector the relay combination *A* and *B* (Figure 1) must be supplied in an additional assembly to give lock-line lamp and rering supervision.

Both types of selectors can be used for multiple switchboard operation as shown in Figure 4 where the system dispatcher, the division distribution operator, and the division office switchboards are all multiple across some of the same carrier-current terminal outputs. The additional codes required are provided on either type of selector by making the first code the basic sequence and adding pulses for codes 2 and 3. Additional "notching" also is required in the code wheel of the mechanical selector.

This application of selectors and supervision on carrier-current circuits allows, to a degree, complete magneto supervision on power-line carriers and telephone-line carriers alike and is utilized in some cases where the carrier terminal is located some distance from the switchboard. Magneto ringing is utilized on the open wire-line drop to actuate the ring-out relay in the carrier terminal to initiate transmitted signals.

DIRECT SUPERVISION AND TRUNKING

UP TO THIS point this article has been concerned with the types of carrier supervision and signaling used with power-line and telephone-line carrier which would fall in a large category of "ring-down supervision," as it would be called in communications parlance.

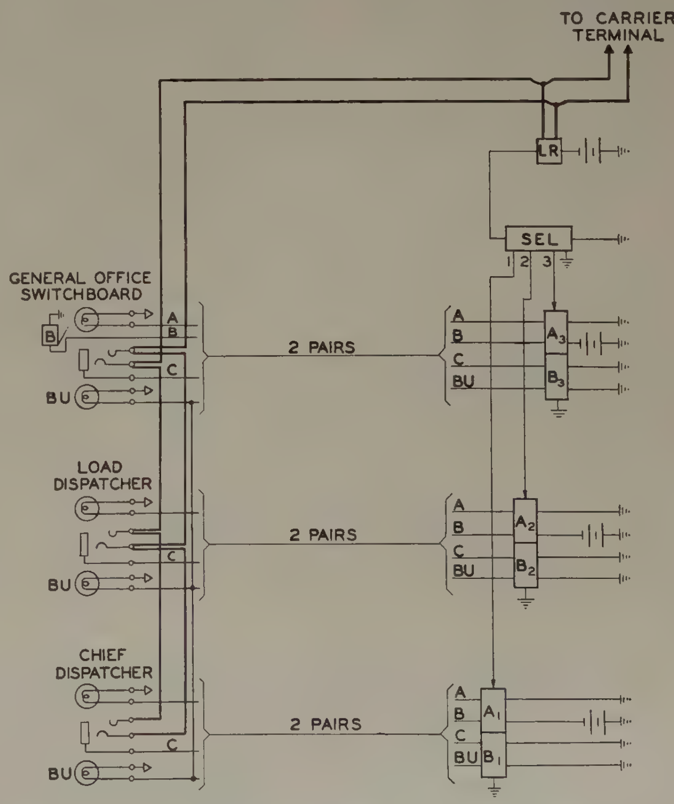

Figure 4. Arrangement of multiple drop supervision from a single carrier-current terminal

Figure 5 shows an arrangement for obtaining full common-battery-type supervision from a group of carrier channels. Full supervision must indicate the same conditions of supervision at both switchboard terminations of the carrier circuit. The carrier trunking arrangement illustrated in Figure 5 takes advantage of the fact that, unlike the carrier terminals described before, these units incorporate separate frequencies for signaling and receiving signals and are designed to incorporate extremely selective band filters so that the signal frequencies do not interfere with the 2,500-cycle-wide voice channel.

Unlike the carrier units that signal in or near the voice band, these units can signal continuously during use of the voice carrier equipment. The carrier transmitters are equipped with signal oscillators as in the first channel in Figure 5 on 3.6 kc. The insertion of a plug into the switchboard jack associated with this channel operates the relay in the carrier trunk, which in turn applies battery potential to start the signal transmitter of channel number 1 from the West switchboard. The voice circuit, shown only as one side of a tip-ring jack, is connected to the primary of a 1-to-1 audio transformer. The secondary of the transformer is coupled to the input of the voice carrier

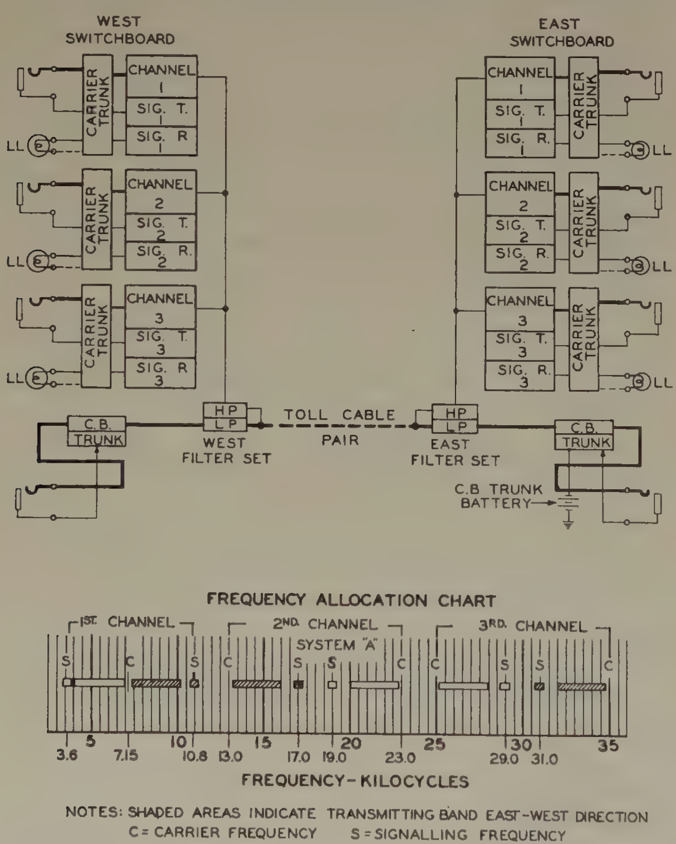

Figure 5. Carrier channels arranged for direct supervision and trunking

unit. The primary of the 1-to-1 transformer in the carrier trunk has its center windings bridging a large capacitor as well as a pair of make contacts in the carrier's signal-receiver output relay. This circuit constitutes a d-c block in the primary of the transformer which holds the West switchboard's cord light energized and therefore indicates a disconnect to the West operator.

The West signal transmitter causes the East terminal's signal receiver to operate, closing the contacts of its output relay which in turn energize the East switchboard's line-lamp, designated as *LL* in Figure 5.

The East channel's signal receiver relay also closes the d-c block across the capacitor-isolated primary of the 1-to-1 audio transformer in the carrier trunk set associated with the East terminal. Upon answering the line-lamp, the East switchboard's operator applies negative battery potential to the carrier trunk relay by inserting a switchboard cord plug. This operates the East channel's trunk-relay which has two functions and one operation. The series circuit from the East receiver relay which energized the line-lamp is opened by its break contacts, extinguishing the East line-lamp *LL*, and its make contacts close to initiate the operation of the East's signal transmitter which, in turn, causes the West carrier receiver relay to close, short-circuiting the isolating capacitor across the center taps of the West carrier's trunks 1-to-1 audio transformer, and this consequent d-c low-resistance loop allows the cord circuit relays to operate and extinguish the cord disconnect lamp, thereby indicating to the operator of the West switchboard that the East switchboard has answered the call.

This type of supervision is equal in an operating sense to the operation of any common-battery telephone manual-exchange service, and lends itself admirably to use between stations where large volumes of communications are to be handled on a full selective basis.

The speed of operation is of prime interest, and the general application of these trunks is one of interconnecting and extending other terminating carrier and line circuits from one main office to another in the power company's communication system. The lower diagram of Figure 5 indicates the frequency allocation and spectrum utilized to operate three such trunks on a single telephone-toll cable pair of wires.

COMBINED TELEMETERING AND CONTROL

Figure 6 illustrates schematically a carrier control scheme for combining a conventional carrier-current telemetering and recording channel with a "fail-safe" valve control system, incorporating a novel control-confirmation indication transmitted from the remote unattended metering station or a main line valve metering point to an attended operating station or compressor station.

The system consists primarily of a telephone-line carrier telemetering transmitter and receiver combination along with its line filter set and graphic recorder of the conventional type used for translating and recording pulse information on a rotary chart.

In addition, the controlling terminus of the circuit is equipped with three pulse-signal sending keys. These keys are cam-cut switching devices with coded wheels arranged for various pulse digit keying of the carrier-current transmitter. The three signal-keys are each equipped with a different digital combination of 17 pulses and are capable of operating only one selector having a like set of digital stops preset within the selector mechanism

and located at the remote end of the circuit.

The rotary chart recorder is equipped with a signal light in its case which indicates the pulses being received from the remote end and functions in accordance with any closure of the telemeter receiver's relay.

The remote unattended end of the circuit is equipped with its line filter set; a carrier-current telemeter transmitter and receiver along with an auxiliary power supply used to energize the *A*, *B*, and *C* pulse selectors; and a keying pole-changing relay installed along with the carrier-current terminal.

The three railroad type pulse selectors designated *A*, *B*, and *C* in Figure 6 are operated in parallel and simultaneously from the pole-changing relay *PC*, which receives its operating pulses from the relay supplied in the output of the carrier-current receiver.

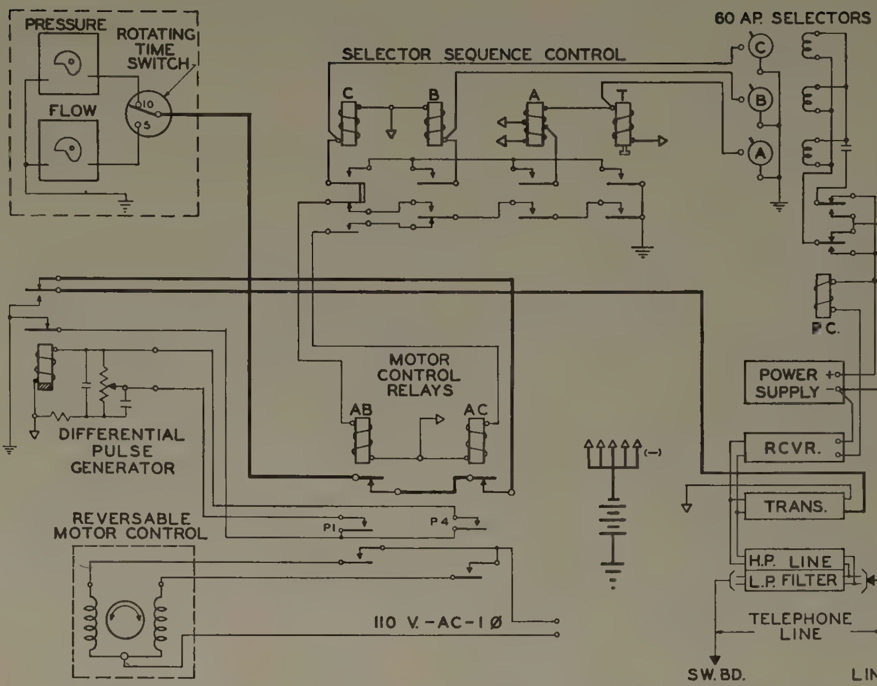

Figure 6. **Carrier-current system combining telemetering and control**

Three selector relays, designated *A*, *B*, and *C*, and a gas-quenched time-delay relay designated *T*, make up the selection bank for the a-c-operated valve motor-control relays *AB* and *AC*. A differential pulse generating relay designated *DIF* is supplied to generate pulses during the operation of the valve motor from the control of the relays *AB* or *AC*.

The remote station is equipped with the conventional pressure and flow telemeter transmitters of the time-division type and an associated a-c-operated selector switch which allows one set of information to be transmitted continuously for 10 minutes and a second set of information for 5 minutes in each 15-minute sequence.

Under normal circumstances the control equipment is completely dormant and the telemetering transmitters, which in turn operate the graph recorder at the control end of the circuit, are telemetering their information continuously. Should the operator at the control station desire to operate the remote valve or switch, he will turn the pulse sending keys *A* and *B*, in turn, and should he desire to close the valve or switch he will actuate the *A* and *C* keys.

The full operation of a valve, for example, might require 15 minutes, which is quite common timing for this type of equipment. The gas-quenched time-delay relay might be set for 2 minutes of operation which, as indicated diagrammatically, will sustain the operation of the *A*, *B*, and *C* selector-relays shown in Figure 6 over a common locking ground contact for the period of its operation only. This of course limits the operation of the valve to 2 minutes, minus the few seconds required for the sending of the *A* and *C* or *A* and *B* codes.

Sending the *A* code and then waiting for possibly $1^1/_2$ minutes before sending the *C* or *B* codes allows a fine degree of valve position adjustment in either direction.

With the idea of failure-safety in mind, the circuit has been arranged so that the operation sequence of all three keys in any sequence, that is, *ABC* or *ACB* or *CBA*, immediately causes failure of the control relays *AB* or *AC*, and therefore furnishes a failure-safe stopping operation.

Contacts are provided on the *AB* and *AC* operating relays to open the operating circuit from the pressure and flow telemetering transmitter to the carrier-current transmitter, and they in turn transfer this initiating lead to the differential pulse generator which functions upon the operation of either the *AB* or *AC* relays. This pulse-generating relay acts to key the carrier transmitter in a series of 4-second marks and alternate 1-second spaces. The operation of the pulse generator allows the operator at the control end to observe the light in the recorder and confirms the operation of the valve by virtue of the pulse difference.

The railroad type pulse selectors are used in this installation to increase the safety factor of operation by transient pulses which might possibly be received by the carrier-current receiver. It would, however, require 34 properly spaced and positive pulses to cause any operation of the control relays. Any operation would be made evident immediately to the operator at the control station by the change in sound and signal of the telemeter recorder's solenoid and the quick pulsing of the light in the recorder's case. This light's normal sequence of 4 pulses per minute would be changed immediately to the comparatively fast flicker caused by the pulsing of the differential pulse generator.

In Figure 6 a 24-volt battery is indicated for selector relay operation, but the auxiliary power supply could be used for power if it were found advisable to eliminate the battery plant.

Frequency-shift or pulse-diversity carrier transmission will lend itself admirably to this system of telemetering and control.

Railway Power Contracts

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RAILWAY POWER CONTRACTS should be based upon rate schedules and general provisions that harmonize the respective interests of the power supplier and user. Elimination of demand charges and the substitution of a straight energy charge supplemented with a minimum bill provision appears to offer the best prospect of reaching this goal. By this means railway managements would be freed from unnecessary restrictions to good operation, and at the same time utility companies would be assured of earning a return on the capital invested in railway power facilities commensurate with the risks involved and with the return from capital devoted to other industrial power services.

Most of the class-*I* line-haul carriers in the United States are bulk freight haulers with small portions of their total train movements devoted to passenger service, long-haul or commuter. Analyses of train sheets show that where freight traffic forms the bulk of the ton-miles handled there is a high degree of inherent time diversity. Hypothetical load curves based on such traffic have revealed a variance in the occurrence of daily peaks. There has been no observed tendency for these daily railway peaks to fall into any invariable pattern, nor has there been any indication that the railway peaks exactly or nearly coincide with the daily system peaks of the remainder of the utility's electrical customers. When the two loads are superimposed the combined load factor is improved and fundamental economies in plant investment are realized.

The conventional industrial power contract is centered in two principal rate factors: a demand and an energy factor. Specified proportions of the total charges are ascribed to each element. Contracts embodying these elements have been fairly successful in harmonizing the separate interests of the power supplier and user in industries other than railroads. In the case of railways, however, the negotiation of a mutually satisfactory power contract never has been too harmonious a process, and the resulting documents have not infrequently been a continuing source of irritation to both parties.

The application of demand charges in railway power contracts is a matter that solicits the utmost discretion and understanding from the supplier. Unlike most industrial power customers, railroads cannot manipulate their demands. The freight traffic which largely determines the magnitude of power demands is offered to them as common carriers in accordance with prevailing general business conditions and must be handled nearly as soon as offered. The total energy requirements will vary almost directly with the total number of ton-miles moved, but the rate at which energy is taken depends on the speed of trains and the times when they reach the ruling grades.

Perhaps the problem of bringing the supplier and user of railway power together can be approached best by reviewing briefly what the demand and energy components of power rates normally are expected to accomplish and then endeavoring to find some alternative basis more acceptable to railroads and at the same time not entirely prejudicial to the interests of utilities.

It is contended that demand and energy charges are levied to cover respectively the fixed and variable costs of supplying power. The demand charge is to cover the capital costs of all facilities devoted exclusively to railway use as well as some allocated portion of the capital costs of joint facilities. The energy charge is to cover materials and labor used up in daily operations. The former relates to costs which accrue whether a single ton moves or not; the latter applies to costs which vary directly with the volume of traffic and the amount of electric energy consumed.

There are at least two ways in which this objective can be approached without resorting to the demand charge. One formula successfully employed for a great many years in one particular railway power contract is a fixed charge of so many dollars per route mile per month. This, supplemented with an energy component, has constituted the basis for power charges and has worked very well. It has freed the railway management from the restrictive influence of ordinary demand charges and, at the same time, has yielded revenue to the power supplier in amounts sufficient to have earned two rate reductions in the past 10 years. Another possible method of recovering fixed charges is through the use of a minimum bill.

Either of the two methods accomplishes the objective of placing a floor under load factor and assures the power supplier that the full capital costs of all special investments in facilities for the exclusive use of the railroad will be recovered irrespective of the volume of railway traffic.

The minimum bill appears more practicable. It can be expressed in simpler terms and tied to a more realistic and stable parameter than route mileage. The minimum bill can best be applied in the form of a straight energy charge with a requirement that not less than a specified amount of money be paid each month. Conceivably, this minimum could be determined separately for each project. It might be easier, however, for a utility to compute average costs and establish a rate schedule which relates these costs to some readily available measure such as total capacity.

A suggested rate schedule might be: 1. energy sold under this schedule shall be paid for at the rate of. . . . mills per kilowatt-hour of net energy delivered, and so forth; 2. the net minimum charge under this schedule shall be. . . cents per month times the aggregate kilovolt-ampere capacity of all points of delivery.

Digest of paper 52-18, "Railway Power Contracts," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Improved Cooling of Turbine-Generator Windings

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TO INCREASE the specific ratings of turbine generators or to build units having larger ratings than are presently possible, a method has been devised for increasing the current-carrying capacity of rotor and stator coils.

The present limitation on the rating of these coils arises primarily from the maximum permissible operating temperature of the electrical insulation and the ability to dissipate the heat loss generated within the coils. For conventional rotor and stator coils, the thermal barrier of the insulation constitutes an inherent obstacle to any major improvement in cooling efficacy. This restriction may be removed by providing a system whereby the coolant removes the heat loss directly by flowing in contact with the copper conductors.

Furthermore, it has been shown that hydrogen at 75 pounds per square inch gauge and flowing at normal gas velocities exhibits an over-all cooling characteristic comparable to that of transformer oil flowing at normal oil velocities. Since hydrogen has become an accepted cooling medium in modern generators, its use in combination with any new cooling system appears desirable and would eliminate many of the complexities attendant to other cooling media.

Figure 1 illustrates an inner-cooled construction proposed for the rotor winding. The conductors are drawn in the shape of channel sections and placed together to form rectangular ducts for the passage of the cooling gas. Two conductors form a parallel turn so that no insulation is required between the legs of the channels. The insulation between successive turns is confined by the channel backs and is entirely removed from the ventilation passages. With this construction, the cooling gas flows axially through the ducts, thus removing the heat directly from the conductors.

Full-size coils have been tested in a ventilation test rig in hydrogen and helium up to 90 pounds per square inch gauge to determine the heat transfer characteristics. These tests have indicated that at hydrogen gauge pressures of the order of 30 to 45 pounds per square inch, it is possible to obtain a more than twofold increase in the current-carrying capacity of a self-ventilated rotor, see Figure 2, or a heat dissipation factor greater than 4. The effect of hydrogen pressure in permitting even greater improvement is quite evident from this curve. Employment of a blower to increase the differential pressure across the cooling duct also is effective in further raising the rating, as shown in the upper curve of Figure 2.

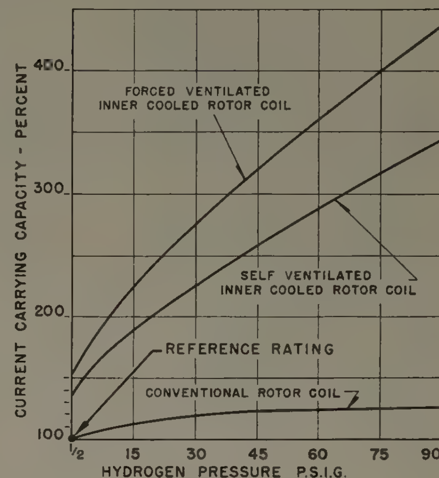

Figure 2. Current-carrying capacity of inner-cooled rotor coil and conventional rotor coil as a function of hydrogen pressure

Mechanical studies and tests have been made to insure that the new coil will be able to withstand the centrifugal and thermal stresses resulting from normal operation.

Although the external dimensions of the stator can be selected so that the stator performance will match that of the rotor, it also becomes advantageous to improve the thermal characteristics of the stator winding. By the use of an inner-cooled construction for the stator coil an appreciable gain may be obtained similarly at moderate gauge pressures. The effect of hydrogen pressure and fan differential pressure again results in further improvement of the stator-coil performance.

The proposed combination of inner-cooled rotor and stator coils does not require the development of radically new manufacturing or operating methods, while the accepted hydrogen control practice is still maintained. Believing that the future merits are promising, the authors' company has undertaken the construction of a large experimental machine based on these principles. The experience gained on this unit will be applied subsequently to the manufacture of large generators now on order.

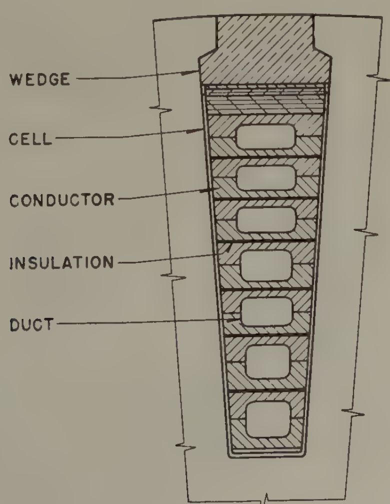

Figure 1. Inner-cooled rotor coil

Digest of paper 52-47, "Improved Cooling of Turbine-Generator Windings," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Engineering Local Television Facilities and Their Operation

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All the means of electrical communication are called into play when a city-wide coverage of an event is to be televised. How telephone and television facilities were utilized on the day that Chicago welcomed General MacArthur is explained in this article.

THE CONSTANT improvement in the quality of the television picture appearing in your home is not necessarily due to new developments such as an improvement in the television broadcast transmitter, home receiver, or a new type of local or network transmission system, but is often due to the steady progress of everyone in their efforts to strengthen weak links in the entire pickup, transmission, and receiving circuit. One element concerned with this fast-growing industry is the telephone company, which is given the task of carrying the video signal from one city to another and to different locations in the same city.

This article will discuss some of the transmission problems encountered in operating video circuits in the Chicago area. The telephone company furnishes video transmission circuits to television broadcasters for use as studio-transmitter links and for remote pickup service. In addition, there has been an increasing demand for services to establish closed-circuit nonbroadcast facilities for use by theater, medical, and industrial groups. Two types of facilities are used to transmit the video signal within the Chicago area:

1. Wire facilities, which may be either regular telephone cable or specially designed video cable; and
2. Microwave facilities, which may consist of point-to-point radio relay operating in the 4,000- or 7,000-megacycle frequency region.

Before discussing the engineering and operation of these facilities, some of their characteristics will be investigated briefly. The various types of cables have different attenuation-frequency characteristics, as shown in Figure 1. The video signal contains frequencies up to approximately 4 megacycles; thus the attenuation characteristic of the cable must be equalized so that the over-all attenuation loss of the channel is uniform throughout this band for faithful transmission. Curve *A* of Figure 1 is for a paper-insulated telephone pair which has considerable loss at 4 megacycles compared to the other types of facilities. It has a low signal-to-noise ratio as each pair is unshielded and adjacent to others which may carry dial pulses, teletype, and so forth. The transmission improvement in regular telephone subscriber and central office equipment over the years has permitted the installation of successively smaller gauge conductors in telephone cable. As a consequence any circuit along a given path may be composed of a combination of 22-, 24-, or 26-gauge conductors. Each gauge cable has a different attenuation-frequency characteristic and at the connection points various impedance discontinuities often are experienced, causing difficulty in equalization; this is one of the problems to be considered. A 16-gauge polyethylene-string-insulated video pair is shown in curve *B*. This cable was designed especially for television use by the Bell Telephone Laboratories and about 90 per cent of the wire facilities in the Chicago area are made up of this type of cable. It has a very good signal-to-noise ratio, as each pair is shielded from all others, and it is very easy to predict the equalization required. This facility will be referred to as polyethylene shielded video (PSV) cable. Curve *C*, cross-country coaxial cable, is not used at present for local video transmission although it has a lower loss than that of PSV cable. The high 60-cycle ground currents that would be induced on the coaxial shield would require the use of transmission carrier frequencies and the cost of carrier

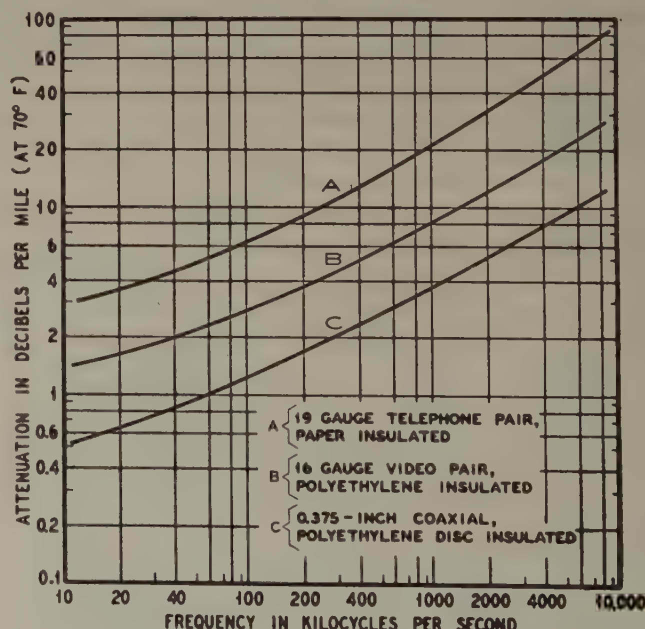

Figure 1. Curves showing attenuation losses of telephone facilities used for video transmission

Revised text of a conference paper, "Engineering and Operation of Local Television Facilities," recommended by the Committee on Wire Communications Systems and presented at the AIEE Fall General Meeting, Cleveland, Ohio, October 22–26, 1951.

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Figure 2 (below). PSV video pairs and telephone pairs which may be used for video transmission

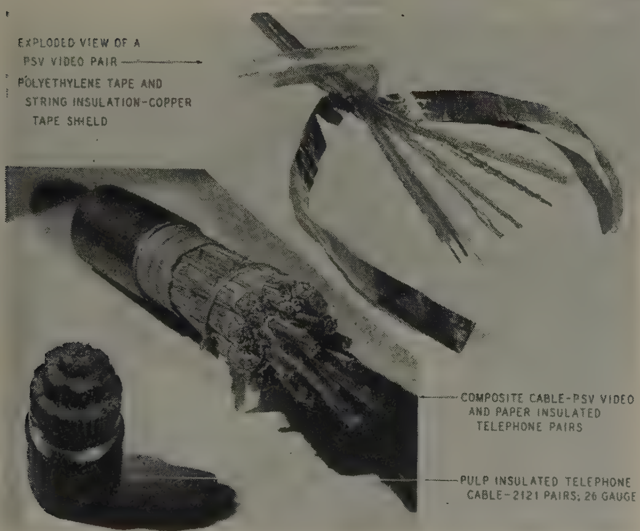

Figure 3 (above). Cross-country coaxial cable used for long-distance telephone or television transmission. An older type of toll cable is shown at the upper right

modulating and demodulating terminals are prohibitive on short-haul circuits.

Figure 2 shows the construction of PSV and paper-insulated cable. Twenty-four PSV pairs will make up a full-size PSV cable whereas 2,121 pairs make up the full-size pulp-insulated cable shown. Cross-country coaxial and an older toll cable are shown in Figure 3.

Microwave transmission is used when insufficient time is available to prepare cable facilities, where the length of the circuit makes it impracticable to use cable facilities, or when it is for only a one-time usage.

Figure 4 indicates the complexities of interconnection involving a number of local video circuits employed to carry the signal from the television camera to the television transmitter. This diagram illustrates how a telephone cable is used to carry the television image from the camera to a telephone company central office where it is amplified and equalized for the cable frequency-attenuation losses, then transmitted by microwave to the control center. The signal then passes by PSV trunk cable to the local television station. The station in turn may feed it back to the telephone company for transmission to the intercity network terminal. A view of one of the amplifiers used to equalize the cable and supply the amplification required

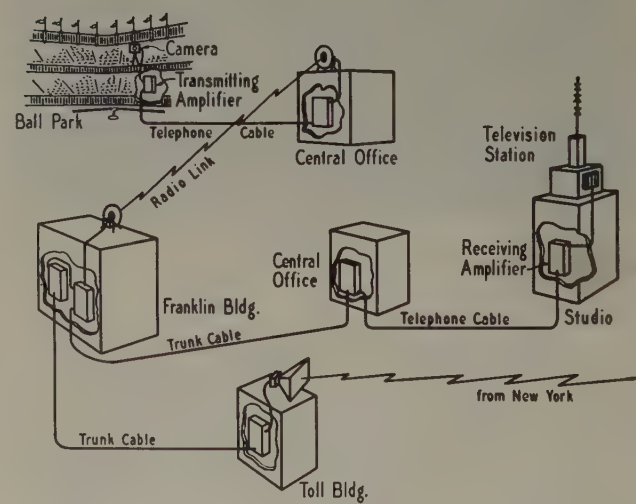

Figure 4. Different types of local circuits which may be used to carry the video signals from the television camera to the transmitter

is shown in Figure 5. This amplifier will equalize $3^1/_2$ miles of PSV cable or approximately 1 mile of the paper-insulated cable. Thirty-five of these amplifiers are located in the Chicago Television Control Center (TCC) and approximately 25 are used on remote pickup circuits distributed throughout the city. A view of the monitoring and test bay of the TCC is shown in Figure 6. All the video signals are brought to the TCC from the various television stations, remote pickup points, and the network connections so that they may be equalized for cable losses

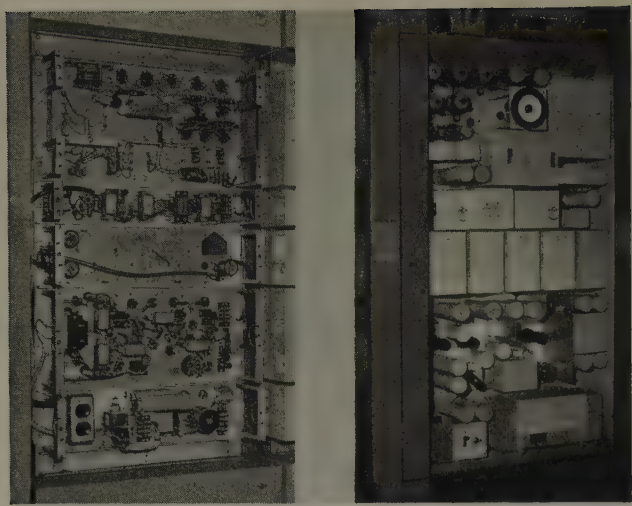

Figure 5. The video amplifier and the equalizer panel used to equalize approximately 3.5 miles of PSV cable. On the left is the wiring side and on the right, the tube side showing equalizer cans

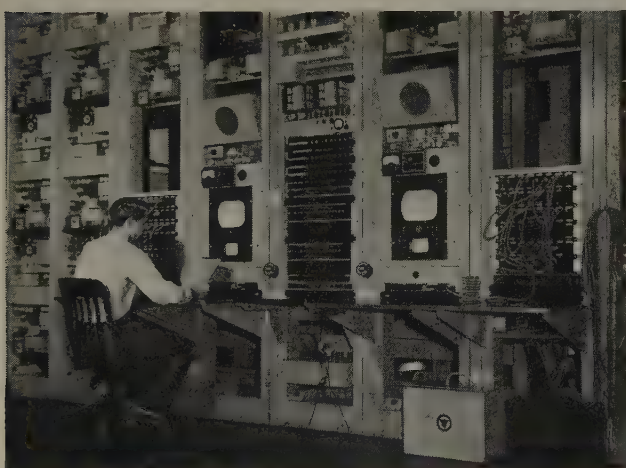

Figure 6. The monitoring and test bay of the Television Control Center

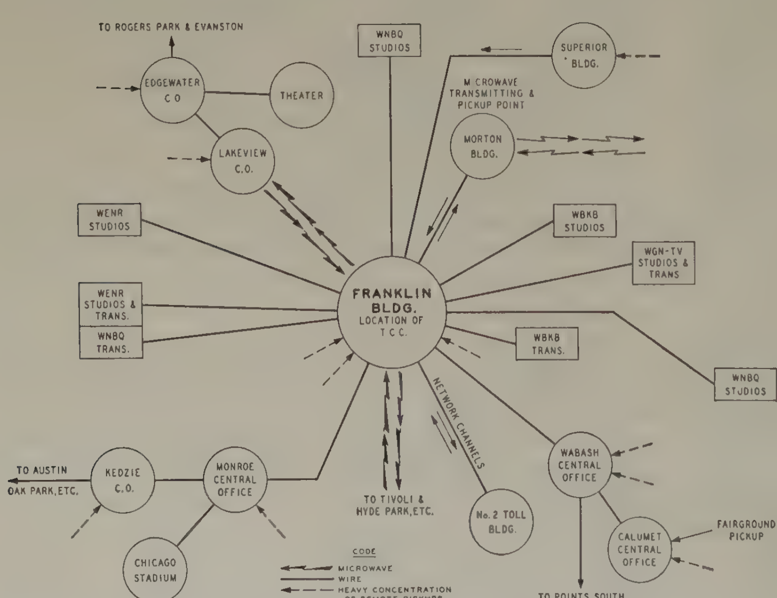

Figure 7. Diagram showing the basic facilities for the local video channels in Chicago and how they converge at the Franklin Building

and monitored for quality of transmission, and also for testing purposes. This control center is centrally located and provides for economical maintenance and a minimum loss of circuit time due to tube and other failures. A simplified diagram showing how video channels converge at the TCC, located at the Franklin Building, is shown in Figure 7. This simplified network has more than doubled in the past year and there is currently a tremendous expansion due to the development of theater network television and the demands for closed-circuit television, color, and black and white.

VIDEO SIGNAL COMPONENTS

Before proceeding to a typical problem, the components that make up a video signal will be considered (Figure 8). The oscilloscope pictures shown are those of a checkerboard pattern. This signal transmits all of the picture detail, background information, and synchronizing information required to complete the process of picture reproduction. It is composed of a combination of frequencies distributed throughout a 30-cycle to 4-megacycle band, also shown in Figure 8. If this signal is transmitted over a video circuit in which the amplitude and phase characteristic is not uniform over this range, then distortion will result and there is a transmission problem. To consider some of the more detailed problems daily coming before a transmission engineer, wire facilities will be discussed next and the problems of microwave installations, even though they may be more interesting, will be passed by.

A typical problem is that of establishing a video channel using two types of cable facilities. Each type of cable will have a different characteristic impedance so that at the junction there will be an irregularity which may cause reflections at various frequencies in the video spectrum (30 cycles—4 megacycles). A frequency run is made over the video channel by transmitting some 30 constant-amplitude sine-wave signals distributed throughout the video spectrum. At the receiving end of the channel the amplitude characteristic is measured with a thermocouple-type power meter which is capable of giving indication of changes in level as low as 0.01 decibel. Figure 9 shows a graph of frequency versus amplitude response for a channel made up of two different types of cables. The mismatch at the cable junction shows up primarily in irregularities centered at 150 kc and 300 kc. By the use of a minimum-loss impedance-matching pad these irregularities were eliminated, as indicated in Figure 9. A severe mismatch will sometimes result in reflections which appear on the screen as ghosts or it may result in picture smearing, depending upon the length of individual cables involved, degree of mismatch, and so on. The effect noted in Figure 9 was picture smear. A minimum-loss impedance-matching pad reduces echo reflection and picture smear type of distortion to a minimum when the impedance mismatch, direction

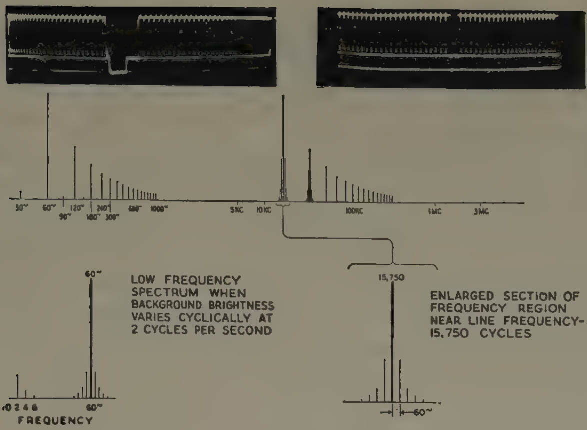

Figure 8. Typical video signal and frequency components in a typical 525-line television signal. A horizontal sync pulse is shown on the left and a vertical sync pulse on the right

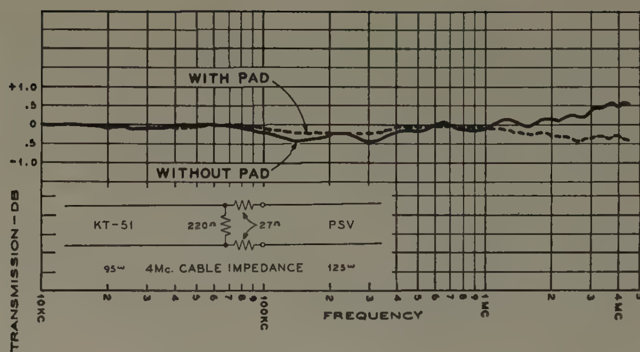

Figure 9. Frequency-response characteristics of a video channel made up of two different types of cables. These two types of cables and their respective characteristic impedances are shown in the insert

of transmission, and cable lengths are favorable for these types of distortions. When short lengths of one type of cable are connected to long sections of another, the distortion is so small that there is no advantage to be gained in impedance matching with the minimum-loss pad.

During the first year of local video transmission in the Chicago area the equalization of all video channels using PSV cable was within the limits of the Bell System practice requirements and was considered very satisfactory by the broadcasters. However, several irregularities in frequency response have been noted recently which are probably the result of gradual changes over a period of time in cable characteristics, splicing, terminations, or equalizers. Thus, the resulting frequency characteristics fell outside of limits for a few of the local video channels which were within limits a year ago. The transmission irregularities which occurred usually are found in the low-frequency region (50–100 kc) and result in picture streaking. Streaking can be defined as either a black or white area of the picture carried across to the right through the rest of the picture, as illustrated in Figure 10. One method of eliminating this streaking condition is to build special mop-up equalizers for each channel to eliminate the transmission irregularity. This has been done for several channels and a frequency-response characteristic before and after the mop-up equalizer was used is shown in Figure 11. The schematic of the 75-ohm constant-impedance equalizer is shown in Figure 11 also.

Streaking similar to that caused by transmission irregularities over cable is often due to improper very-low-frequency response (30–120 cycles) of a video amplifier. Most commercial broadcast-quality video amplifiers, including those of the telephone company, have a low-frequency adjustment control. The setting of this control at a television station will depend upon the camera chain amplifier response, but the setting of the control at the telephone company will depend upon the telephone company amplifier response and the response of the equalized video cable. One peculiarity noted is that proper adjustment of the telephone video amplifier cannot be made unless the frequency response of the channel meets certain limits from 5 kc to 220 kc, even though the low-

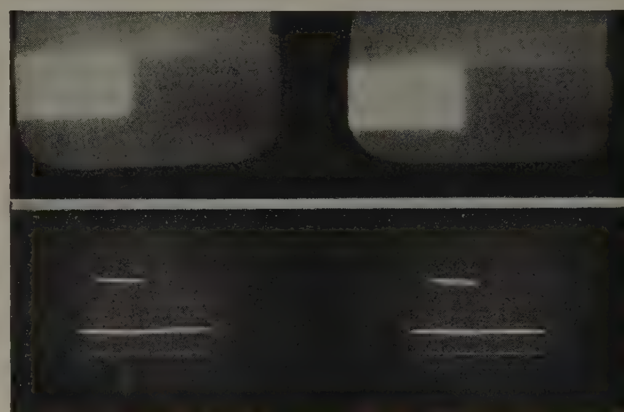

Figure 10. Streaking over a video transmission path may result from transmission irregularities occurring in the camera, studio equipment, video channel, transmitter, or receiver. This illustration has been processed several times and the contrast ratio has been increased as a result. Mop-up equalizer in use when left picture was made and no mop-up used in the other

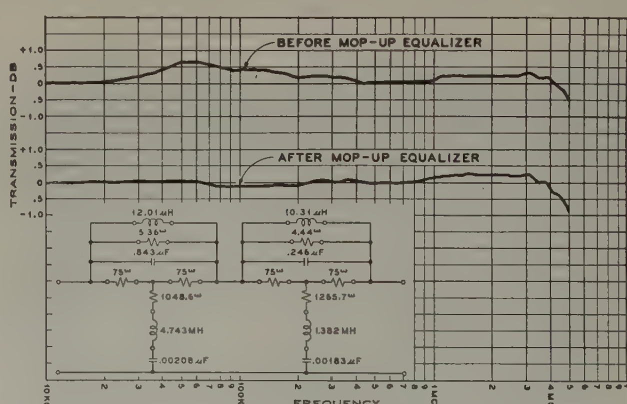

Figure 11. The frequency-response characteristic of a video channel before and after mop-up equalization. Figure 10 was made at the end of this channel. The schematic diagram of the mop-up equalizer is shown in the insert

frequency adjustment controls the 30–120 cycle range. It may be noted that all of these frequencies are within 20 times the respective line and field repetition rates of the video signal. A mathematical analysis of the energy

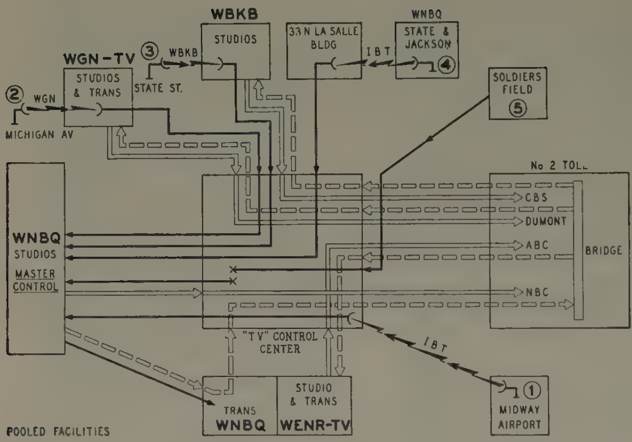

Figure 12. In this schematic of the network established within 24 hours for television coverage of MacArthur Day in Chicago, the solid lines indicate the individual pickup to the master control; the dotted lines the feed from master control to individual stations; and the open lines the feed from the individual station to network

Figure 13. On the right is the television camera aimed at General MacArthur's plane upon its arrival in Chicago Midway Airport; in the left foreground is the telephone company's microwave transmitter

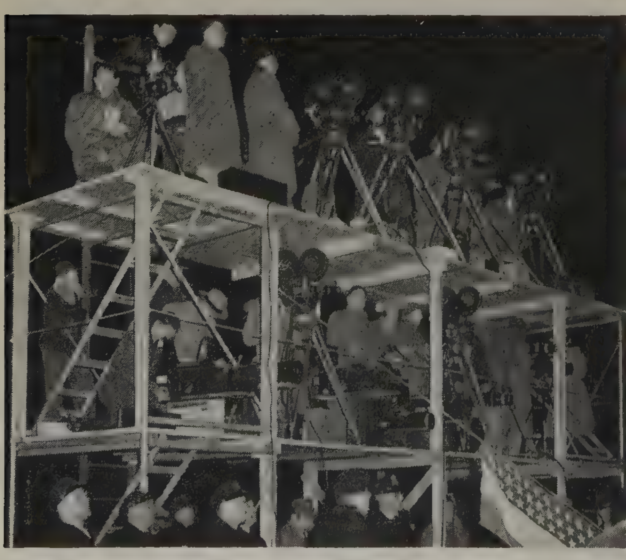

Figure 14. The temporary television, moving-picture, and news camera gallery erected at Soldiers Field. This was one of three television camera locations

spectrum of a video signal (Figure 8) shows that these frequency ranges are in the region of most energy concentration.

Another peculiarity that may be noted is that streaking seems to be a cumulative type of distortion. If present in the original signal from the camera, although all following equipment is streak-free, it will be accentuated as it passes through successive amplifiers and television channels. However, if not present in the camera and all following pieces of equipment are streak-free, streaking will not develop nor be increased as it was in the preceding case. In working with this problem of streaking one is often concerned with a marginal quantity and it was found that valid results were obtained only when test equipment was positively streak-free and all technical personnel at the broadcaster's studio and local and network control centers understood the importance of precise adjustment and maintenance of equipment under their control.

PEAK SERVICE REQUIREMENTS

A PROBLEM OF AN operational nature confronting the telephone company is how to meet peak service requirements when someone like General MacArthur visits the town unexpectedly. At noon on April 25, 1951, General MacArthur landed at the Chicago Midway Airport and an estimated 20,000,000 television viewers were able to be with MacArthur from that time until the end of the day at Soldiers Field. Approximately 100 miles of Illinois Bell wire and microwave circuits were utilized for the greatest coverage of any planned event in the city's history. Definite plans for covering the ceremony were not complete until the day before his arrival. Thus, the entire network to provide the complete coverage shown in Figure 12 was set up in less than 24 hours. The four Chicago television broadcasters pooled their equipment and manpower for this event, while retaining most regular studios and channels for stand-by and fill-in service.

As illustrated in Figure 12, the first pickup point was at the Chicago Midway Airport where the *WENR-TV* camera crews televised the landing of the *Bataan* and fed the picture into the microwave relay system which beamed it to the top of the Franklin Building, the location of the television control center. The signal then proceeded by cable to the Merchandise Mart studios of *WNBQ*, designated the master control point for the entire broadcast. The channels shown by the dotted line then carried the image back to the long-lines control center in the Number 2 Toll Building and then to each television station for broadcast.

As General MacArthur and the welcoming parade moved along Michigan Avenue (pickup point number 2, Figure 12) *WGN-TV* cameras picked up the scene and microwaved it to their studios; from here the image was transmitted to the Franklin Building by PSV cable and thence to the Merchandise Mart as in the preceding case. At pickup point number 3 (State Street and Wacker Drive) the *WBKB* cameras covered the event as illustrated in the diagram.

Pickup point number 4 was located at State and Jackson

Streets, where *WNBQ* camera crews recorded MacArthur's progress along the street which was lined solidly with people wishing to get a glimpse of the procession. The cameras at this point were located at the second floor of a building having a good vantage point and the image was transmitted to the top of the building by cable and then beamed by Illinois Bell Telephone microwave to the top of another downtown building where PSV cable facilities were available to carry the signal to the TCC.

The last pickup point was made during the evening hours at Soldiers Field (pickup number 5, Figure 12), where the *WGN-TV* cameras routed the television image to the permanent Illinois Bell circuits used to make the television coverage of events at Soldiers Field. This coverage required the use of practically all available Illinois Bell and television broadcaster facilities and dramatically demonstrated the value of close co-operation between broadcaster and common carrier in order to serve the public in the best way possible.

Figure 13 shows the *WENR-TV* camera aimed at the *Bataan* and the Illinois Bell microwave transmitter beaming the picture signal downtown to the Franklin Building. Figure 14 shows the television camera installation, movie news camera, and press galleries erected at Soldiers Field for the evening coverage.

Some of the problems in the engineering of local telephone facilities which are used as a link in the television broadcasting chain have been covered here. Because of the possibility of interconnecting any combination of local video channels, each channel (which may consist of both wire and microwave facilities) must be equalized within close limits. One weak broadcaster's or telephone-company link in the chain would deteriorate the entire transmission. The operating problems solved during the coverage of the MacArthur Day ceremonies will serve as a valuable guide in planning for the Democratic and Republican conventions to be held in Chicago in 1952. Because of the nation-wide interest in these events it is expected that this network will be even more complex than that required for MacArthur Day.

Theory of Electric Spark Machining

E. M. WILLIAMS
MEMBER AIEE

The electric spark machining process is assuming industrial importance in the tool and die industry. A typical electric system for this process is described and a theory advanced for the mechanism of its operation together with results of experimental tests.

THE ELECTRIC spark process for the machining of hard metals is in extensive use abroad and has been introduced recently in the United States.[1] This system permits the rapid cutting of accurate and, if necessary, intricate shapes in such materials as sintered tungsten carbides, S-816, vitalium, hardened steels, and hard alloys of titanium, zirconium, vanadium, and so forth, which are ordinarily not machinable. This process is now used for the finishing of hollow jet-turbine blades, turbine blade roots, thread and rifle gauges, nozzles, bodies with reentrant surfaces, and so forth. The basic features of this process are described as well as the results of an experimental and theoretical study of the phenomena involved.

In the electric spark machining process, as described by Lazarenko[2,3,4] and others,[5,6,7] a succession of high-current sparks are caused to pass between a work piece and an electrode having the shape of the hole which it is desired to pierce through the work piece. The sparks are derived from the discharges of a capacitor, shown in Figure 1. Each spark more or less completely discharges the capacitor; following this the spark path is deionized and the capacitor is recharged from the d-c source through the charging resistance. During the process, material is removed from both electrode and work piece and the electrode is advanced manually or automatically[8,9] until the machin-

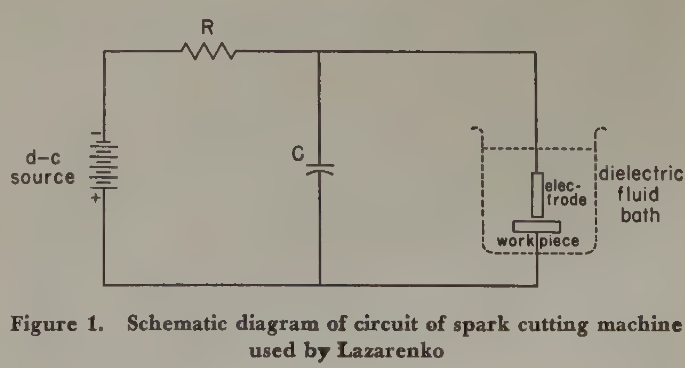

Figure 1. Schematic diagram of circuit of spark cutting machine used by Lazarenko

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ing operation is complete. Lazarenko has shown that cutting speed is greatly increased if the electrode polarity is negative with respect to the work piece and if the gap between electrode and work piece is immersed in a dielectric, commonly kerosene or transformer oil. An automatic spark-cutting machine is shown in Figure 2 and

Figure 2. Spark cutting machine now used in the United States is on the left and its control cabinet on the right

some samples of tungsten carbide machined by this method are illustrated in Figure 3.

The physical phenomena associated with the process are as follows. The electrode, connected permanently to the negative lead of the charged capacitor, is advanced through the dielectric toward the work piece which is connected to the positive electrode of the capacitor. When the gap between electrode and work piece is reduced to a sufficiently small value, of the order of 0.003 inch per hundred volts, the dielectric breaks down and a discharge takes place. The range of working voltage in production machines is from approximately 40 to 400 volts. Oscillographic measurements of typical discharges show that the discharges are oscillatory with a range of peak currents from a few hundred to about 20,000 amperes and frequencies of from 10 to 1,000 kc. Each discharge is accompanied by explosive sounds, spattering of oil, and evolution of gas bubbles, smoke, light, and heat; these effects are particularly pronounced at the higher voltages and currents. Following the discharge, the gap deionizes. It is probable that deionization is assisted by the liberation of hydrogen in the spark region through chemical decomposition of the dielectric fluid, such as occurs in oil circuit breakers. Following deionization, the capacitor recharges and the electrode advances until a voltage is reached at which breakdown again occurs. Typical spark repetition rates range from 50 to 5,000 discharges per second. The detached fragments of the work piece and electrode material are removed by the dielectric flow resulting from the local pressures caused by the explosive discharges. This removal may be augmented by forced circulation of the dielectric fluid. The duty cycle is extremely low due to the low recovery rate of capacitor voltage necessary to avoid arc formation and the time required for removal of eroded material.

The holes produced are larger than the electrode by the gap spacing corresponding to the breakdown distance associated with the peak capacitor voltage under any particular operating condition. Variations in the gap due to variations in electrode and work piece surface

Figure 3. Sintered tungsten carbide pieces formed by spark cutting machine. Two engraving dies are shown on the left; second from right is a die used in textile manufacture; and on the right is a step drill tip

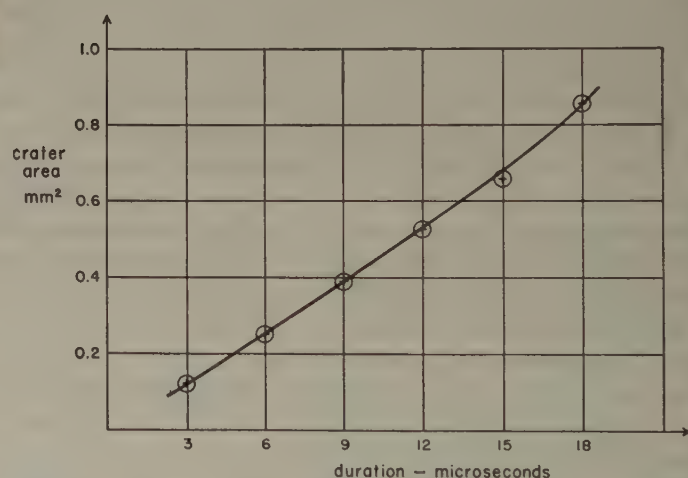

Figure 4. Area of crater in sintered tungsten carbide resulting from a single capacitor discharge between brass electrode and plane surface of work piece as a function of half-cycle duration of a 5,600-ampere (peak) oscillatory discharge in microseconds. This discharge is sufficiently damped so that only initial half-cycle has appreciable effect on crater

configurations as machining proceeds result in a rough machined surface. For fine finishing cuts this and other effects are minimized by using very low voltages and capacitances.

Spark machining is slow by comparison with conventional machining methods for soft materials; rates of

material removal, for instance, are of the order of 1 gram per minute. The process is commercially feasible for very hard materials, however, as it permits the forming of desirable tool and die shapes unobtainable by alternative means and, where alternative means exist, this process is often more economical of material and time.

A study has been made of the erosion produced by single sparks in transformer oil between an electrode and a plane tungsten-carbide surface under conditions corresponding to fairly rapid and rough machining by the electric spark process. In these tests, peak currents, frequencies of the oscillatory discharge, and gap spacing were varied and the depth and area of the craters produced were studied by means of a microscope. In each case, rough craters were produced which were characterized by a well-defined area of nearly constant depth.

Experimental data, (the average of a large number of observations) are plotted in Figures 4, 5, 6, and 7. Figures 6 and 7 have been plotted with ordinates normalized to show particular relations to be discussed hereafter. It is apparent that crater depth depends on the magnitude of discharge current while crater area is very nearly proportional to discharge duration. Material removed by sparks of varying amplitude and fixed duration is roughly proportional to the three-halves power of peak discharge current. Other measurements show that gap width (corresponding to voltage with which the capacitor is charged as instant discharge takes place) has little effect on crater depth and area, but is significant in that the crater location with respect to electrode position becomes increasingly erratic as the gap width is increased. Operating voltage thus has an important effect on machining accuracy for this reason, in addition to its effect on the variations in the critical gap previously discussed.

Electrode material has little effect on the dimensions of the crater produced in the work piece. Erosion of the electrode itself, however, varies considerably between materials and is also a function of the electrode form. Differences in erosion between various electrode materials are very much decreased when thin tubular electrodes are used.

The spark erosion process in which erosion is greatest at the positive electrode is evidently quite different from arc-cutting systems in which the greater erosion takes place at the negative electrode. Arc erosion is accompanied by high temperatures and melting, whereas in the spark erosion process microscopic examination of the work piece surface gives evidence of fracture by mechanical forces. Analyses of residues from spark machining of sintered tungsten carbides, for instance, give no evidence of physical or chemical changes that might be associated with high temperatures or melting of the tungsten carbide. Machined surfaces exhibit no alteration in temperature-related properties such as surface hardness. Crystallographic studies of machined surfaces of material with transformation temperatures slightly above ambient have shown that machined surface temperature rises are insufficient to produce such crystal transformations. Therefore, it may be concluded definitely that material is removed without melting.

Several theories have been advanced to explain spark erosion. Lazarenko has suggested electrolytic action and "electrodynamic" forces of an undisclosed nature. Mandelshtam and Raiskii[10] have propounded a theory in which erosion is due to the explosive force of the discharge

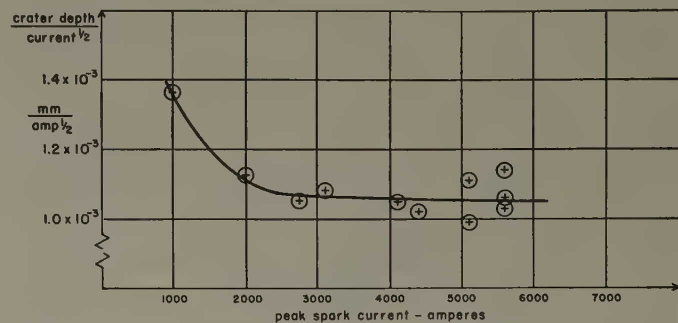

Figure 6. Effect of peak current of single oscillatory discharge of constant frequency on crater depth expressed as a function of ratio of crater depth to the square root of current, showing dependence of crater depth on square root of current at higher peak currents

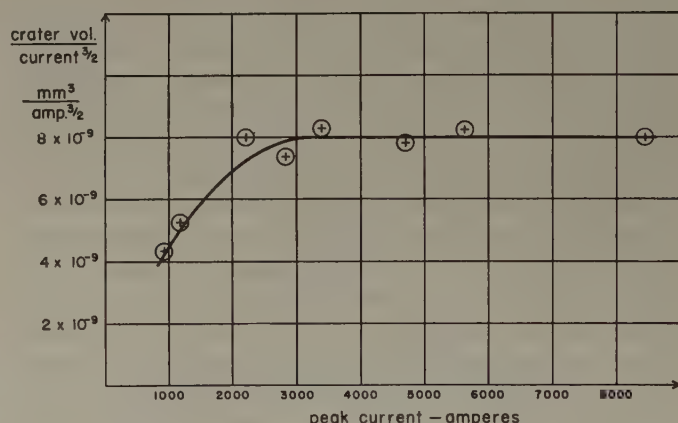

Figure 7. Effect of peak current on volume of crater under the conditions of Figure 6, expressed as a function of ratio of crater volume to square root of current cubed, showing dependence of crater volume on square root of current cubed at higher peak currents

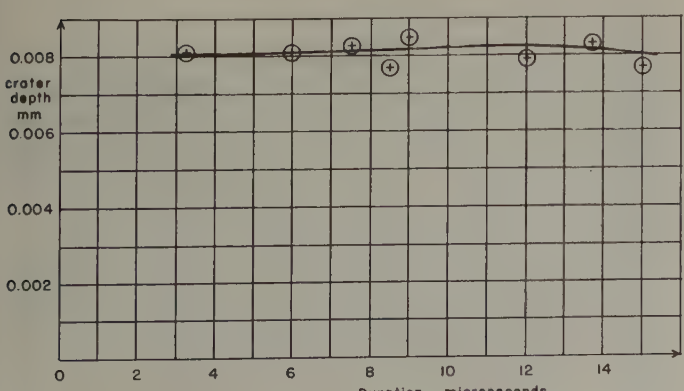

Figure 5. Depth of crater as a function of spark duration under the same conditions as those of Figure 4

augmented by a high-temperature metal-vapor flare propagated from the cathode (electrode) toward the anode (work piece). Rudorff[11] has suggested that oscillating mechanical forces, similar to those involved in cavitation, are involved. Evidence in support of these theories, however, is qualitative in nature and inconclusive.

A very satisfactory quantitative correlation with experimental results has been obtained, however, for a theory which accounts for a major component of the erosion by electric field forces. These forces arise because of the extremely high current density at, about, and beneath a point on the surface of the work material and a correspondingly high electric-field gradient and force on the positive ions of the crystal lattice. The magnitude of the forces involved may be estimated from a knowledge of the crater depth and area produced by a known discharge current. In a typical instance, a current of 5,600 amperes produced in sintered tungsten carbide a crater 0.0085 millimeter deep and 0.078 square millimeter in area. The peak surface current density J_s may be estimated from the peak current and crater area as, at least, $J_s = \frac{5600}{0.078} =$ 71,700 amperes per square millimeter or about 7,170,000 amperes per square centimeter. The resistivity of the tungsten carbide sample is about 28×10^{-6} ohm-centimeter so that the normal component of the electric-field gradient E_s just beneath the surface is $E_s = 201$ volts per centimeter. The number of free electrons (which is equal to the number of positive ionic charges) in a relatively good conductor such as tungsten carbide is of the order of magnitude of the number of metal atoms.[12] In tungsten carbide, this criterion indicates a positive charge density of 5.8×10^3 coulombs per cubic centimeter, or in the fragment corresponding to the crater in this case a charge of 3.9×10^{-8} coulomb. The force on the fragment is thus 0.784×10^7 dynes or 17.6 pounds. This is equivalent to a stress at the bottom of the fragment, neglecting shear stresses on its sides, of 145,000 pounds per square inch, which is sufficiently in excess of the breaking strength of the material to account for fracture. According to this theory a larger fragment than that observed is not detached because the normal component of current density decreases below the surface due to spreading of the current, which is undoubtedly augmented by skin effect. Erosion of the electrode material is due to (1) the oscillatory nature of the spark discharge in which the electrode becomes positive in the second half cycle, and (2) erosion of the soft electrode material by the stream of hard work piece particles removed from the work piece.

This electric field force hypothesis as to the nature of the erosion force provides explanations for the curves of Figures 4 to 7 as follows:

Figures 4 and 5. Crater depth is independent of spark duration while crater area is directly proportional to spark duration, because in the course of a single discharge several fragments are detached in sequence from adjacent areas with the entire current of the discharge terminating on each area in turn. The actual current density in the discharge at any time is, therefore, considerably greater than that estimated from the total crater diameter. Since the depth of the crater remains constant with variations in spark duration, a constant current density provides a more plausible explanation for the variation of crater diameter with spark duration than that the spark current density decreased with time as suggested by Somerville and Blevin.[13]

Figures 6 and 7. If the spark is considered as a point current source on the surface of the work piece and skin effect is neglected, the current density J_r at any distance r from the point is

$$J_r = \frac{I}{2\pi r^2}$$

If a critical current density J_c is required for removal of a fragment at radius r, the radius at which this current density exists will be

$$r = \sqrt{\frac{I}{2\pi J_c}}$$

and the radius of the crater should be proportional to the square root of the spark current. Figure 6 is a plot of the ratio of crater depth to the square root of the current versus current and it is apparent that at higher currents crater depth is very nearly proportional to the square root of the current. A similar reasoning may be applied to show that volume of material removed, as in Figure 7, should be very nearly proportional to the three-halves power of the current. Deviations of the data from predicted forms at low currents may be explained as due to presence of surface imperfections of the same general magnitude as the craters and to a condition in which the craters are so small that the sparks cannot be considered point sources.

Numerous improvements in the speed and accuracy of spark cutting machines have been effected through redesign of these machines and their associated circuits in the light of the electric field force theory.

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Supercharged Hydrogen Cooling of Generators

STERLING BECKWITH
FELLOW AIEE

SUPERCHARGED HYDROGEN COOLING of generators represents a forward step in the steady progress to reduce the size of frame and the amount of material needed to obtain a given rating. Figure 1 shows a 60,000-kw generator with a supercharged rotor, tested a year ago, which has been in service for some time. Its active core length is 60 per cent of that of a normal machine and power plant space is reduced correspondingly.

Supercharged cooling employs cooling gas flowing at exceptionally high velocities in direct contact with the copper conductors. The supercharger is a 2-stage centrifugal compressor mounted at the exciter end of the rotor shaft just inboard of the hydrogen seal. Interference with rotor removal thus is avoided The cleanliness of hydrogen makes direct contact with the copper feasible, and this direct contact eliminates the large thermal drop through the slot insulation.

The key to supercharged cooling is to reach the threshold of gas flow which will permit the supercharging gas to absorb all the I^2R loss without raising its temperature above the allowable limit. This threshold of flow is not easy to reach because of the large drop in gas pressure due to friction drop at the velocities involved. Electric machines with cooling gas in contact with the conducting copper are not new, but no case has been described previously in which the required threshold of gas flow was reached.

The permissible increase in rotor I^2R of a typical supercharged machine when housing pressure is raised from 1/2 pound per square inch to 15 pounds per square inch gauge is about 100 per cent, which means that 40 per cent more field current and 170 per cent load are permissible. Stator cooling, however, is usually a limitation on rating when supercharging is applied only to the rotor. This can be augmented by deeper slots, by more stator ventilating ducts, and by spiral ventilation of the core. Even so, the increased rotor heat discharged into the air gap tends to sustain stator temperatures. Consequently, the supercharging of the stator, in addition to the rotor, is now under way and promises still further gains in output. At a gas pressure of 25 pounds per square inch gauge the completely supercharged machine is expected to permit $2^1/_4$ times the present rating of a given frame.

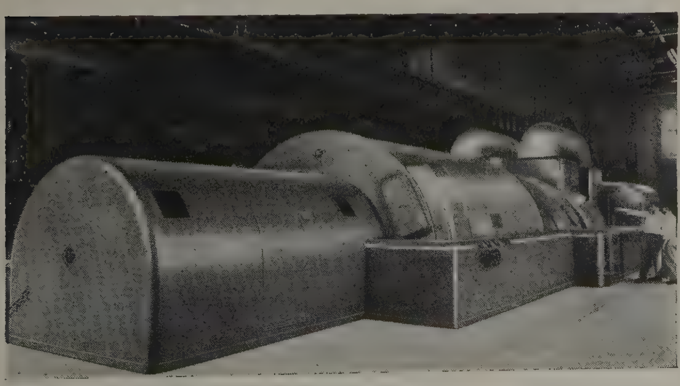

Figure 1. The 60,000-kw steam turbine generator, Edgewater Station, Wisconsin Power and Light Company, Sheboygan, Wis.

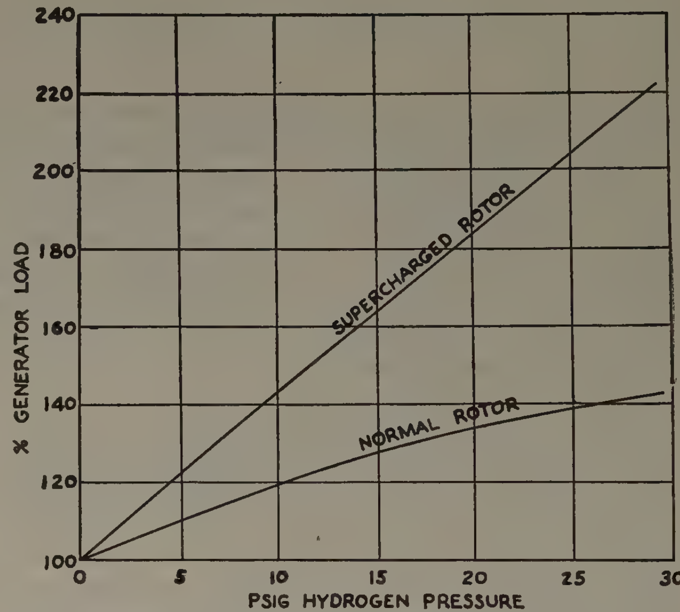

Figure 2. Overload versus hydrogen pressure for constant temperature rise of rotor by resistance

The gas used in supercharging a rotor is diverted from the suction side of the outboard stator cooling fan, passes through the 2-stage compressor and through the end portion of two of the main coolers. It then divides, half entering each end of the rotor through flutes in the shaft.

In addition to savings in material and space requirements, the new design affords substantial reductions in foundation loading as well as in the size of bearings, seals, oil piping, and pumps. The short length and the low temperature difference between copper and iron mean reduced differential expansion on both stator and rotor. Balancing problems are simplified because of reduced length.

The efficiency of a supercharged machine is improved at light loads. Its increased reactances permit savings in circuit breakers and bus structure, and afford lower coupling and turbine torques under fault conditions than for normal design.

As shown in Figure 2, based upon actual tests, the supercharged generator will carry far greater overload with elevated pressures than a normal machine.

Digest of paper 52-32, "Supercharged Hydrogen Cooling of Generators," recommended by the AIEE Committees on Rotating Machinery and Power Generation and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Expansion of Thermoelectric Generating Capacity in Italy Under ECA Sponsorship

FREMONT FELIX
MEMBER AIEE

Marshall Plan aid to Italy is helping that country to overcome an acute shortage of electric energy and to speed its recovery. Steam plants are being constructed to supplement the predominant hydroelectric facilities to avoid future shortages due to poor hydrological conditions.

IT IS THE purpose of this article to outline briefly the unusually interesting and concentrated expansion of one country's electric generating capacity as made possible by the joint efforts of the planning and building resources of the country itself and by the extremely efficient use of the funds and services made available under the Marshall Plan.

In his capacity of representative of one of the American manufacturers who are supplying a large part of the generating equipment the author has been closely, and practically continuously, associated with this activity in Italy since its very inception. It is only fair to state that he has been deeply impressed, both by the farseeing conception of the program and by the admirable manner in which it is being carried out by the expertly directed Italian utilities as well as the Italian Government bodies and by the Marshall Plan administrators.

PURPOSE AND SCOPE OF PROGRAM

ITALY ALWAYS HAS had a predominance of hydroelectric power. In consequence, the poor hydrologic conditions of 1949 to 1950, in combination with the shortage due to the devastation and failure to expand caused by the war (strikingly evident in Figure 1), led to a considerable shortage in the availability of electric energy. This spurred the allocation of Marshall Plan funds towards the restoring of a more equitable percentage in steam capacity, at the same time as the acute over-all deficiency of energy was being remedied by the promptest possible means. Thus, through the provision of the necessary electric power, a big step is being taken toward the Economic Cooperation Administration (ECA) objective of assisting Italy in every way possible to carry out its broad program of activities and to fulfill its important role in the recovery of Europe.

The ECA program also is intended to help boost the electric energy availability in the less developed parts of Italy, especially the southern and the insular portion, as brought out in Tables I and II, which together with Figure 2 show the full geographic and economic scope of the program in its application to the four major areas of widely different economic (and kilowatt-hour) status.

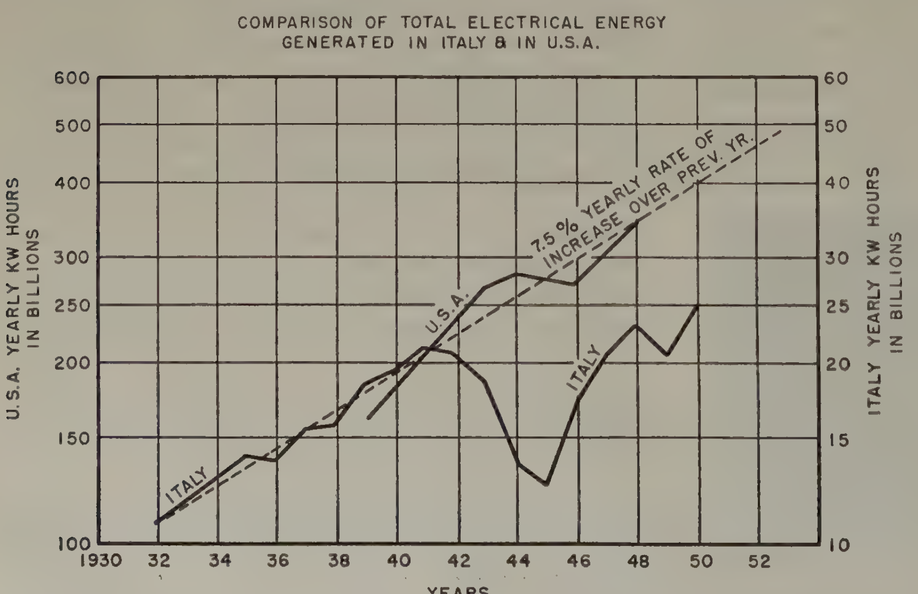

Figure 1. Comparison of total electric energy generated in Italy and the United States

STEAM AND ELECTRIC CONDITIONS

THERE HAS BEEN a very fortunate and helpful meeting of minds, between the various utilities concerned, toward standardization, so that most of the turbine-alternators are being built, or considered, for 850 pounds per square inch gauge, 900 degrees Fahrenheit turbine temperature, except that 1,450 pounds per square inch gauge, 1,000 degrees Fahrenheit turbine temperature, and 1,000 degrees reheat is selected where natural gas will make possible the use of these power plants as base stations, with a very high load factor.

Most of the alternators are being supplied for 13,800 volts, 50 cycles.

The extent of the standardization achieved can be judged by

Fremont Felix is representative for Italy of the International General Electric Company, New York, N. Y. Among the Economic Cooperation Administration personnel who have assisted in the planning and execution of the Italian Power Program are: Walker Cisler, Chief Power Consultant, Washington, D. C.; George H. Knutson, Projects Branch Chief, Washington, D. C.; Everett Eslick, Chief of the Electric Power Branch, Washington, D. C.; the late C. W. DeForest, Chief of the Electric Power Section, Paris, France; R. E. Fisher, former Power Adviser for the ECA Rome Mission; W. S. Shepard, present Power Adviser for the ECA Rome Mission; George Sutherland, Chief of the Electric Power Section, Paris, France; and S. F. Neville, Deputy Chief of the OSR Electric Power Section.

the fact that 11 out of the 12 turbine-alternators of American manufacture represented in this program are of only four types, which presents obvious advantages from the standpoint of maintenance, spare parts, and so forth.

Of the three sources of fuel which the power plants in Table II will utilize, the most interesting from the standpoint of the utilization of the natural resources is natural gas, about 95 per cent pure methane, with a calorific content of 1,000 Btu per cubic foot. This is being developed rapidly in increasing amounts in Lombardy, in the Po Valley, and its utilization will probably be extended to the entire peninsula.

The other important source of fuel will be the Sardinian coal from the Sulcis basin, the production of which is also being intensified with Marshall Plan assistance.

Finally, provision also will be made to burn imported liquid fuel, and many of the boilers under erection are being equipped to handle either of two or three of the fuels, according to future conditions.

PARTICIPATION OF AMERICAN FIRMS

As made possible by Marshall Plan financing, a very complete cross section of American firms is participating both in the consulting engineering phase and in the supply of major pieces of equipment, thus resulting in making of these new power plants excellent "show cases" of United States power plant technique.

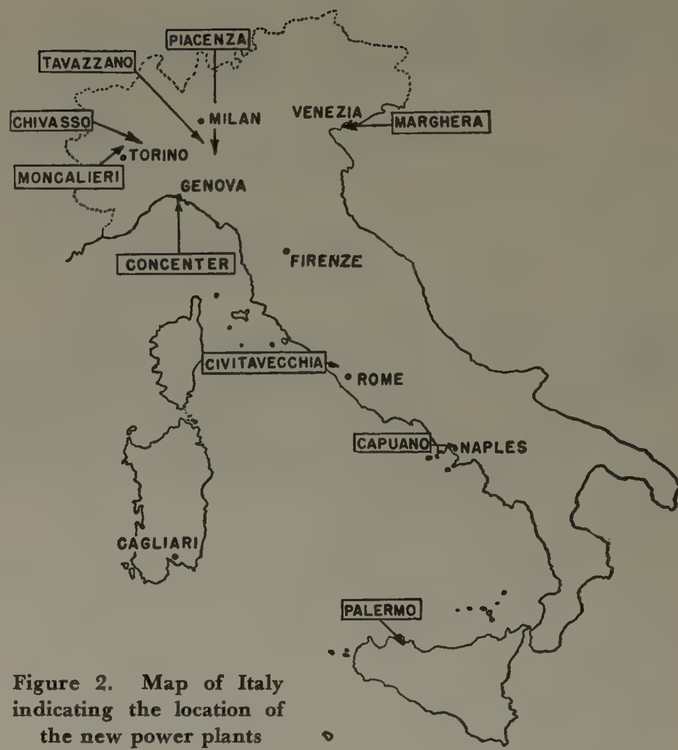

Figure 2. Map of Italy indicating the location of the new power plants

At the time of writing, construction is proceeding actively on all power plants and, benefiting from pre-Korea delivery schedules, although this program is less than 2 years old, major pieces of equipment already have arrived on site.

It is expected that, barring adverse developments, operation will be initiated on all power plants before the end of 1952.

Table I. New Power Plants Constructed in Italy with ECA Aid

ECA Financing Year	Utility	Power Plant	Rated Kilowatts	ECA Grant, Dollars
1948 to 1949	Soc. Edison	Concenter 1° (Genova)	60,000	6,000,000
1948 to 1949	Soc. Meridionale di Elettricita	Capuano 1° (Napoli)	30,000	3,432,000
1948 to 1949	Soc. Termoelettrica Siciliana	Palermo 1°	30,000	6,300,000
1948 to 1949	Soc. Termoelettrica Siciliana	Palermo 2°	30,000	
Total 1948 to 1949			150,000	15,732,000
1949 to 1950	Soc. Edison	Concenter 2° (Genova)	60,000	6,169,000
1949 to 1950	Soc. Edison	Piacenza 1°	60,000	9,323,000
1949 to 1950	Soc. Edison	Piacenza 2°	60,000	
1949 to 1950	Soc. Idroelettrica Piemonte	Chivasso 1°	60,000	6,215,000
1949 to 1950	Soc. Termoelettrica Veneta	Marghera 2°	60,000	6,558,000
1949 to 1950	Soc. Meridionale di Elettricita	Capuano 2° (Napoli)	60,000	6,143,000
1949 to 1950	Soc. Termoelettrica Tirrena	Civitavecchia 1° (Roma)	60,000	6,110,000
Total 1949 to 1950			420,000	40,518,000
1950 to 1951	Az. Elettr. Municip. Torino	Moncalieri (Torino)	30,000	3,517,000
1950 to 1951	Soc. Termoelettrica Italiana	Tavazzano 1° (Milano)	60,000	3,000,000*
1950 to 1951	Soc. Termoelettrica Italiana	Tavazzano 2° (Milano)	60,000	
Total 1950 to 1951			150,000	6,517,000
Grand Total			720,000	62,767,000

* The turboalternators and their auxiliaries for this power plant were obtained in Europe without ECA financing.

Table II. Regional Breakdown of Power Generation in Italy

Region	Population	Kilowatt-Hours, 1950	Kilowatt-Hours per Capita	Present Total Kilowatts	Present Steam Kilowatts	Added Steam Kilowatts	Per Cent Steam Addition of Total
Northern	20,200,000	18,678,820,000	920	4,731,076	626,523	510,000	10.8
Central	10,100,000	3,162,630,000	310	737,314	345,370	60,000	8.15
Southern	10,000,000	2,517,460,000	252	704,738	85,935	90,000	12.6
Insular	5,700,000	354,820,000	62	129,844	127,410	60,000	46.8
Total	46,000,000	24,713,730,000	535*	6,302,972	1,185,238	720,000	11.4

* In 1938 these kilowatt-hours per capita were 335.

PARTICIPATION OF ITALIAN MANUFACTURING

The Italian participation in the way of civil construction, transformers, and so forth, is approximately of the same order as the equivalent American contribution; thus the Marshall Plan assistance may be considered to have an amplification factor of 2 to 1.

The high degree of expertness which characterizes the Italian utilities will combine with the possibilities provided by the use of the most modern American equipment into the realization of a group of power plants which will set new standards of technical efficiency and achievement. At the same time, they will provide a most potent factor towards the rapid progress of Italian economy which has proved so strikingly the excellent use it can make of electric power in every phase of its activity.

Contact Resistance—The Contribution of Nonuniform Current Flow

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FELLOW AIEE

W. T. SACKETT, JR.
ASSOCIATE MEMBER AIEE

Both experimental and theoretical studies indicate that spreading resistance forms an important part of the resistance of contacts and that it can be controlled over wide limits by varying the number of parallel conducting spots.

WHEN TWO metallic surfaces are brought together the surfaces never make uniform contact over the entire area. The actual contact occurs only at small subareas. This phenomenon gives rise to what is known as the resistance of contacts. This resistance consists of two parts: a resistance at the contact, R_c, due to adsorbed gases, oxide layers, or grease films at the small subareas; and the spreading resistance, R_s, resulting from the nonuniform flow of current in the body of the materials.

This article presents a study of the contribution that the spreading resistance makes to the total resistance of metals in contact. The spreading resistance was determined experimentally and theoretically for both round rod and flat strip specimens in which a restricted current path or constriction was introduced by machining away part of the material. The influence of the size, location, shape, and number of the constrictions on the spreading resistance was investigated.

SPREADING RESISTANCE

THE RESISTANCE of a long uniform rod is given by $R=p(L/A)$ where p is the specific resistance, L the length, and A the cross-sectional area.

When a constriction is introduced in such a rod, the current flow is no longer uniform. Figure 1 shows a plot of the equipotential lines determined experimentally for a flat strip specimen having a sharp constriction. The current flow becomes substantially parallel within a distance equal to the width of the specimen. The spreading resistance is due to the reduction of current density in the corners which results in an increase in resistance.

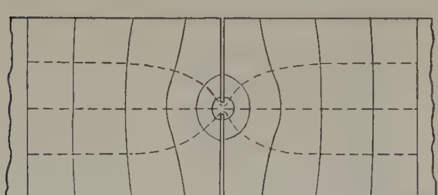

Figure 1. Equipotential and flow lines on flat strip with constrictions

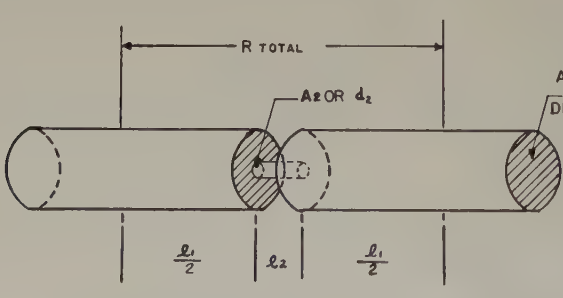

Figure 2. A typical round rod test specimen

The spreading resistance is the only resistance that exists between two clean, film-free metal surfaces in contact. The spots where actual contact is made will be of various shapes and sizes randomly located throughout the apparent contact area, and the resistance resulting from the nonuniform current flow will constitute the total contact resistance.

The method adopted for the study of the spreading resistance was to measure the increase in resistance produced by making lathe or saw cuts in the central section of a specimen. A typical round rod specimen is shown in Figure 2.

Each specimen was first checked for uniformity of dimensions and resistance and then its resistance between two knife edges 8 inches apart was measured in a Kelvin double-bridge circuit. Then the central section was machined to the desired constriction. When this was completed, the resistance was measured again.

The spreading resistance, R_s, was determined from these two resistance measurements as follows. From the results of the first measurement the resistance R_A per unit length and the specific resistance of the sample was calculated. In addition, the resistance R_a per unit length of the reduced section was determined. If R_0 equals the resistance of the rod after the constriction was made, then

$$R_s = R_0 - (R_A l_1 + R_a l_2)$$

where l_1 is the rod length of diameter d_1, and l_2 the length of the constricted portion of diameter d_2; see Figure 2.

EXPERIMENTAL PROCEDURE

THE MEASUREMENTS were made with direct current using a special Kelvin double-bridge constructed for the purpose. During the measurements each sample was immersed in an oil bath. Standards for each different specimen tested were made from the same material to simplify the temperature problem. Care was taken to

Full text of paper 51-140, "Contact Resistance—The Contribution of Nonuniform Current Flow," recommended by the AIEE Committee on Electric Welding and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Published in AIEE *Transactions*, volume 70, part I, 1951, pages 791–95.

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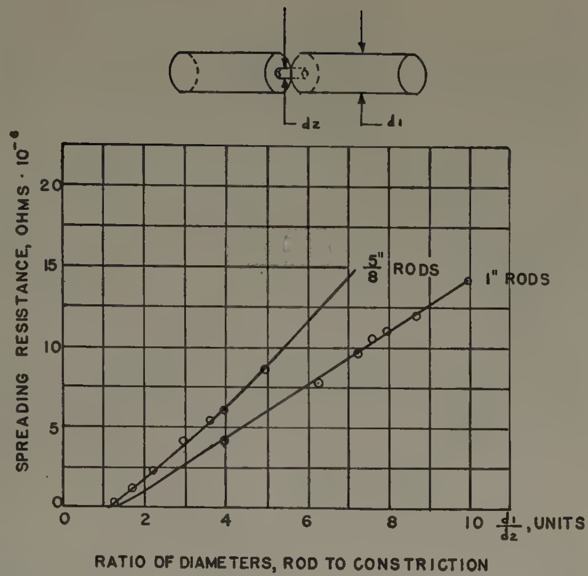

Figure 3. Spreading resistance of round rods for constrictions of varying sizes

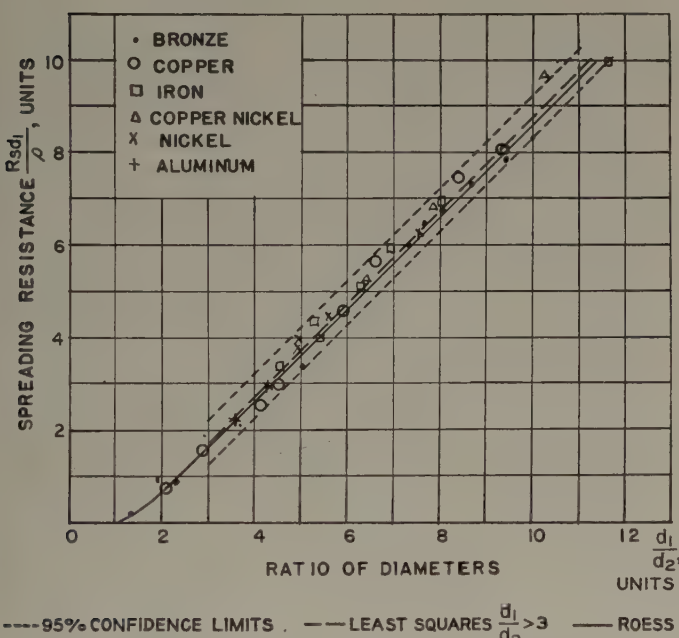

Figure 4. Spreading resistance of round rods expressed on a per-unit basis

avoid local heating. At all times the accuracy of the measurements was better than 1 part in 1,000. This was found to be ample as the spreading resistance proved to be larger than anticipated.

The spreading resistance for two bronze rods having diameters of 5/8 inch and 1 inch respectively and concentric constrictions of different amounts are plotted in Figure 3. In the figure the abscissa is the ratio of the diameter of the rod to the diameter of the constriction and the ordinate is the spreading resistance. A study of Figure 3 makes it clear that for each diameter of rod there is a separate curve when the results are plotted to these co-ordinates. The results, however, may be expressed on a per-unit basis[1] by multiplying the spreading resistance by the rod's diameter d_1 and dividing by the specific resistance. Thus, when the ordinate of the curve is $R_s d_1/p$, it will be found that all of the points lie on the same curve irrespective of diameter and material.

The results found for concentric constrictions on aluminum, bronze, copper, copper-nickel, iron, and nickel rods ranging in diameter from 0.45 inch to 1 inch and with varying size constrictions are plotted in Figure 4. These points when plotted on this per-unit basis all lie on a smooth curve that checks closely with the solution of the Laplace equation for this boundary value problem as given by Dr. L. C. Roess in "Theory of Spreading Conductance," an unpublished report of the Beacon Laboratories of the Texas Company, Beacon, N. Y.

In the mathematical solution of this problem, certain assumptions were necessary. The validity of these assumptions is confirmed by the experimental measured values. A statistical analysis of the results shows that the least squares line closely coincides with the linear portion of the theoretical curve, and that the 95-per-cent confidence limits embrace a narrow band. These also are plotted in Figure 4.

The spreading resistance was measured on a number of flat strips of brass with a constriction located at the midpoint of the strip. A typical specimen is shown in Figure 5. The results of these measurements also are plotted in Figure 5 where the abscissa is the ratio of the width of the strip to the width of the constriction and the ordinate is on a per-unit basis $R_s w/p$. Here w is the thickness of the strip. The solid curve is based on Smythe's mathematical solution.[2] The experimental points check this solution.

In practice the length of the constricted path is usually quite small. The question therefore arose: does the length of the constricted path have any effect upon the spreading resistance? Measurements were made on round specimens in which the length of the constricted path was varied from 0.163 to 0.007 inch. Within experimental limits the spreading resistance was found to be independent of the length of the constriction, and the points fell on the smooth curve of Figure 4.

On actual contacts the constricting area is not located

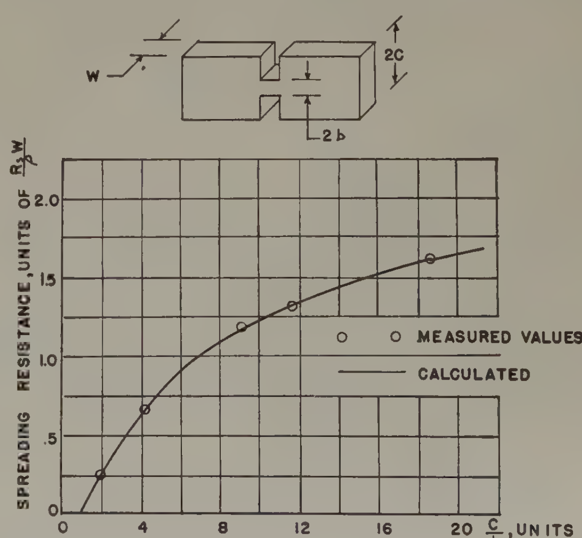

Figure 5. Spreading resistance of flat strips

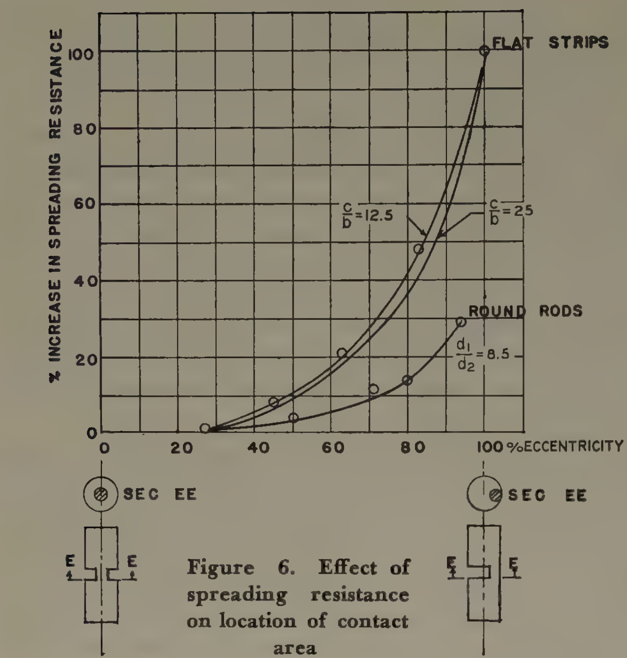

Figure 6. Effect of spreading resistance on location of contact area

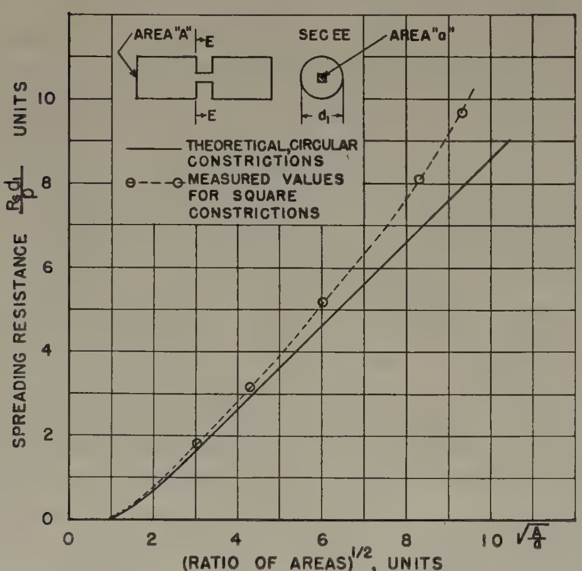

Figure 7. Spreading resistance of round rods with square constrictions

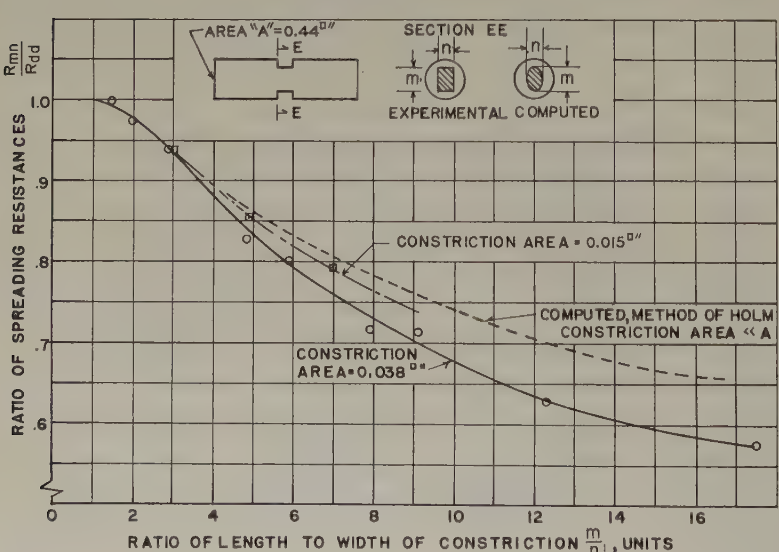

Figure 8. Variation of spreading resistance with shape of contact area

symmetrically, but may be at any point on the surface. The effect on the spreading resistance produced by nonsymmetrically or eccentrically located constrictions was studied for both flat and round specimens. Specimens were made in which the constriction was held to a fixed size and on successive specimens its location was varied from the center to the extreme edge. The results are plotted in Figure 6 for a ratio of $d_1/d_2=8.5$ for the round specimens and for the ratios of $c/b=12.5$ and 25 for the flat samples.

A study of Figure 6 shows that the location of the contact spot does not have much effect on the spreading resistance until the eccentricity exceeds 50 per cent for strip specimens and 60 per cent for round ones. The effect is naturally greater for flat strips because in these the flow lines are restricted more severely than in the round specimens. It also was found that as the area of the constriction was reduced the effect of nonsymmetrical location was slightly less marked, as also may be seen from the figure.

SHAPE OF THE CONTACT AREA

It is also true in actual contacts that the shape of the contact area will not be circular. Where contact occurs by virtue of metal being squeezed into fissures made in surface films by high contact pressures, there would be a fairly high degree of "ellipticity" of the contact areas. Therefore an experimental study of the influence of the shape of the constriction was made.

The spreading resistance of round rods having square symmetrical constrictions was determined for different constricting areas. A comparison of these measurements with the results for circular constrictions is shown in Figure 7. The dimensionless quantity $R_s d_1/p$ is plotted as ordinate against $\sqrt{A/a}$ as abscissa. A is the cross-sectional area of the round rod, and a that of the constriction. The curve gives the results for round constrictions, while the circled points are measured values found for square constrictions. The points fall slightly above the curve, but the deviations from the curve are within the limits of experimental error.

The next step in the exploration of the shape effect was to test a series of samples having rectangular constrictions with the same total area, mn=constant. It was then possible to determine the relation of spreading resistance to a shape factor, here defined as the ratio of the length m to the width n of the rectangular constriction.

Holm has shown[8] that the effect of the shape of the constriction can be calculated if one assumes the constricting area to be an ellipse of area much smaller than the cross-sectional area of the rod. Then, if R_{mn} is the spreading resistance for an elliptical constriction with major axis m and minor axis n, and if R_{dd} is the spreading resistance of a circular constriction of diameter d

$$\frac{R_{mn}}{R_{dd}}=\frac{K(k_1)}{\pi}\left(\frac{4d}{m+n}\right)$$

where $k_1 = \frac{m-n}{m+n}$. k_1 is the modulus of K, a complete elliptical integral of the first kind.

The dotted curve of Figure 8 is a plot of this equation. In addition there are given in Figure 8 the experimental curves for two rectangular constrictions; one of 0.015 square inch and one of 0.038 square inch. All three curves coincide for an m/n less than 3, where the constriction is well centered. The curve for the smaller area more nearly fits that of Holm's formula.[3] It is perhaps worth comment that for a given total constricting area a long thin constriction gives appreciably less spreading resistance than a round constriction, but the magnitude of the decrease would be less than 25 per cent for reasonable shapes.

PARALLEL CONSTRICTIONS

Study of the contribution of spreading resistance to contact resistance should involve an inquiry concerning the effect of two or more constricting paths in parallel across the contact surface. When force is applied to the contact members, the yield point of the first contacting areas is reached quickly and flow occurs until enough of the apparent contact area is in load-bearing contact to reduce the pressure below the plastic flow limit of the metal. During this process the number of conducting constrictions that form will depend on the surface shape and finish. Holm[4] states that the total load-bearing contact area S_b will be relatively constant for a given contact load (P) and contact material, and is of the order of magnitude $S_b = 2P/H$, where H is the upper limit of the contact pressure at which plastic flow or splintering occurs.

Windred[5] has stated, "When there is more than one contact point, there may be electromagnetic interactions between the lines of current flow if the contact points are close together, otherwise this may be neglected." Holm[6] uses the phrase "the constricted lines of flow influence each other" if the conducting spots are close together. Both state that if the spots are far apart, total spreading conductance can be computed by adding the conductances of individual spots.

The concept of the flow lines of parallel constrictions influencing each other is misleading and that of self or mutual electromagnetic forces on flow lines under steady flow conditions is probably erroneous. To check this the following experiment was devised. Consider the brass strip with a constriction (2-dimensional flow) as shown in Figure 9A. The flow is symmetrical about the center line; hence, the total resistance of the strip between knife edges V_1 and V_2 should be exactly half that of the individual halves of the strip. If the strip is separated at the center line and put together as in Figure 9B exactly the same resistance should be obtained between the knife edges barring disturbance of the flow by electromagnetic forces.

This experiment was performed on several brass strip samples, and each time the spreading resistance of a sample constructed as shown in Figure 9B was found to be equal to the corresponding sample Figure 9A, within the experimental limits. Hence, one can conclude that mutual electromagnetic forces of parallel flow have no practical effect on spreading resistance.

This does not mean, however, that the spreading resistance of parallel constrictions is independent of the spacing between them. It was found that the spreading resistance for single constrictions changes with their location, as shown in Figure 6. The influence of the spacing of parallel constrictions on the spreading resistance was studied on 13 brass strip samples. Each strip was 1.5 inches wide and 1/8 inch thick and each had two symmetrically located parallel constrictions of 0.062 inch wide. All factors were held constant except that the spacing was varied from zero to the maximum possible value. The data are plotted in Figure 10 where the abscissa is the

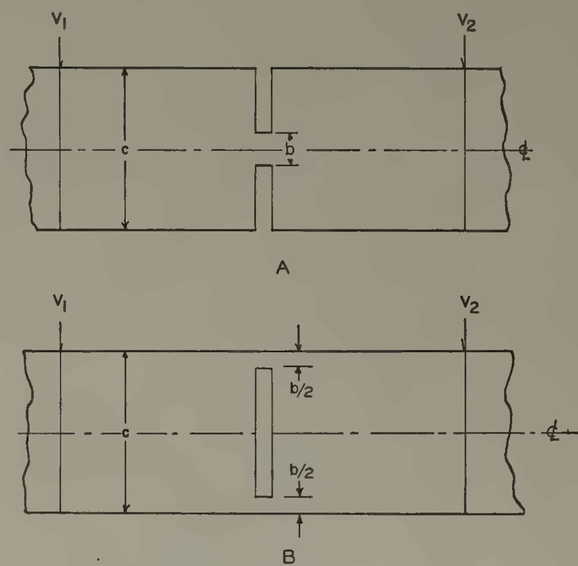

Figure 9. Flat specimens with either one or two constrictions

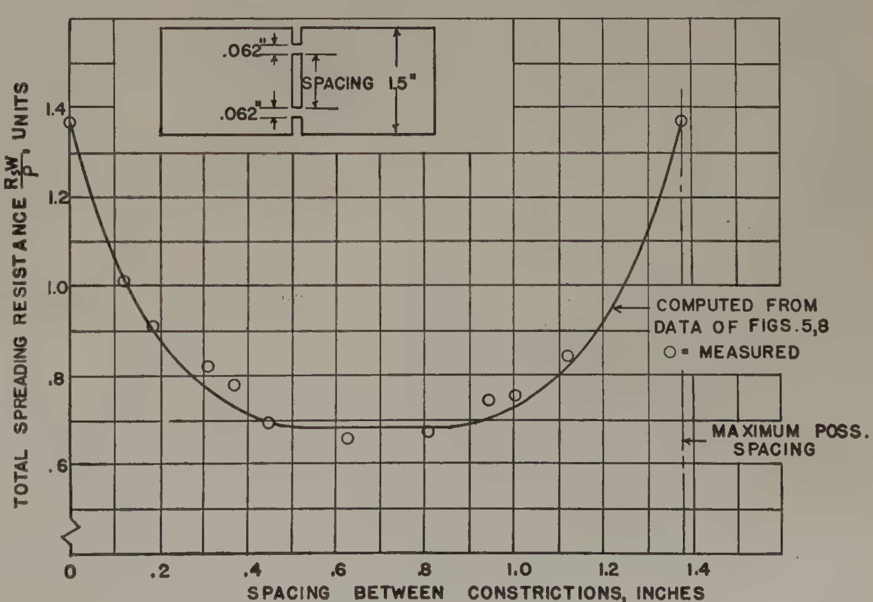

Figure 10. The effect of the location of parallel constriction upon the spreading resistance

spacing between the constrictions, and the ordinate is the dimensionless spreading resistance R_sW/p. The solid curve of Figure 10 was computed from the data of Figures 5 and 6 by considering the single strip as consisting of the parallel connection of two separate strips half as wide with eccentrically located constrictions. The circled points are the measured values for the 13 specimens.

It was found that the spreading resistance for two parallel constrictions separated by half the strip width was exactly half that obtained when the spacing was zero (single constriction 0.124 inch wide).

CONTROL OF SPREADING RESISTANCE

Assuming that Holm is correct in his statement that the total contact area is dependent mainly on the load and the materials in contact,[4] it follows that the total contact area may be concentrated in a single spot or may be distributed randomly in small subareas over the surface. The question arises as to what effect this has on the resulting spreading resistance and how this resistance may be controlled. The experimental work indicates that the spreading resistance of two metals in contact may be controlled by varying the number of contact points. For any given total contact area, the lowest spreading resistance will be obtained with the maximum number of symmetrically located constrictions or contact subareas. As the number of contact points is increased, while keeping the total contact area constant, the resulting spreading resistance approaches zero, even though the area of the individual constriction or contact point also approaches zero.

The verification of this statement is based on the following analysis. It has been shown experimentally that the value of the spreading resistance in ohms for a flat strip specimen with a symmetrical constriction varies with the ratio of the width of the strip to the width of the constriction. For a given ratio the spreading resistance is constant provided the thickness of the strip is constant.

Assume that we have a strip of width c and thickness w with a symmetrical constriction of width b and a thickness w. This strip will have a spreading resistance of R_s ohms. Assume now that this strip is replaced by two strips each of width $c/2$ and each with a symmetrical constriction of width $b/2$, both strips having the thickness w. Now each half-strip will have a spreading resistance R_s identical to that of the full-sized strip.

If these two strips are joined in parallel, their individual spreading resistance R_s will be in parallel also and the resultant spreading resistance will be $R_s/2$. This is confirmed by the experimental results, Figure 10.

Assume now that each half-strip is divided into two strips of width $c/4$ and each with a symmetrical constriction of width $b/4$. Each one of these four strips will have a spreading resistance of R_s equal to that of the original full-sized specimen. When these four strips are joined in parallel, the resulting spreading resistance will be one-fourth of R_s.

It is evident from the analysis that the resulting spreading resistance of a specimen with a large number of parallel paths approaches zero as the number is increased, provided the total constricting area remains constant. The spreading resistance is a maximum for a single contact point of the given area.

A similar analysis may be developed for round or square rod specimens. The analysis is given for a square bar, as it has been shown in Figure 7 that in a round bar a square constriction and a circular constriction of the same area give very closely the same spreading resistance.

Assume a square bar of W inches on a side and of cross-sectional area A_1, having a symmetrical constriction at the center of A_2 square inches. This bar will have a spreading resistance $R_{s1}=Rp/w$, where R is the per-unit spreading resistance.

Now assume that this square bar is divided into quarters each of $W/2$ inches on a side, each of cross-sectional area $A_1/4$ and each having a symmetrical constriction of area $A_2/4$. Each one of these quarters will have a spreading resistance of $R_{s2}=Rp/(W/2)$, or twice that of the original bar. When these four quarters are joined in parallel, the resulting spreading resistance will be one-half of that of the original bar with its single symmetrical constriction. This process of subdivision may be repeated indefinitely and so the statement is verified.

From this analysis it is evident that the spreading resistance can be controlled by using the proper surface finish of the contact areas. The maximum spreading resistance will be obtained if there is a single small area of contact, as in a projection weld. The spreading resistance may be reduced to a minimum by using a surface finish that provides a large number of contact points or constrictions scattered throughout the area.

CONCLUSIONS

The results of this study provide an explanation of spreading resistance, and curves are presented for calculating its magnitude for single and multiple constricting contacts. The study shows that:

1. The spreading resistance forms an important part of the resistance of contacts.
2. The theoretical analysis given by Roess for symmetrical constrictions is confirmed experimentally.
3. Off-center location or eccentricity of the constriction increases the spreading resistance, but the effect is small until the constriction is near the edge of the material.
4. The shape of the constriction effects the spreading resistance.
5. The spreading resistance can be controlled between wide limits by varying the number of parallel conducting spots.

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4. Ibid, page 2.

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6. **Ragnar, Holm,** op. cit., page 19.

Motor-Driven Exciters for Turbine Generators

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THE PURPOSE OF this article is to point out the important factors involved and describe a reasonably simple method of calculating the required characteristics of motor-driven exciters for turbine generators. Such calculations are required to insure that the performance of the motor-generator set exciter will be comparable to that of a directly connected exciter during system disturbances. Although the method can be applied to any type of auxiliary supply system, the material in this article applies specifically to the auxiliary system in the Elrama Station of the Duquesne Light Company, Pittsburgh, Pa. A schematic diagram of this station is shown in Figure 1.

Large motor-driven exciters have several operating advantages over directly connected exciters as a result of their independent drive. The primary disadvantage of a motor-generator exciter is that it may be actually or effectively disconnected from its power source during system faults and the subsequent switching operations. During these periods of very low voltage the motor-generator set will slow down, reducing the exciter voltage and response. Sufficient flywheel can be added to limit the minimum speed to a reasonable value and the exciter can be designed to have characteristics at this minimum speed equivalent to a directly connected exciter. Since the speed and decelerating forces are dependent upon the inertia constant, the exciter characteristics, and the severity of the fault, the differential equation for an exact solution is very complex. A step-by-step calculation is the most practical way to determine the change in speed during fault conditions.

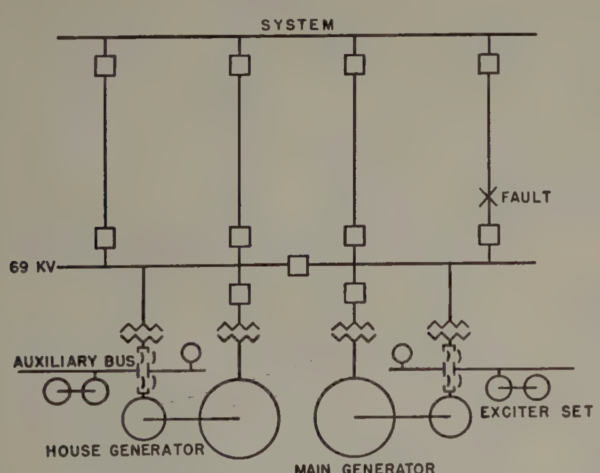

Figure 1. Simplified single-line diagram of the Duquesne Light Company's Elrama Station showing the assumed fault location

Relaying times and system stability determine the length of time for which the exciter must operate without power input. The calculations take into account the change of generator field current during the fault, the action of the voltage regulator and pilot exciter, and the energy output of the exciter set. The results of the calculations are exciter speed and voltage, as shown in Figure 2.

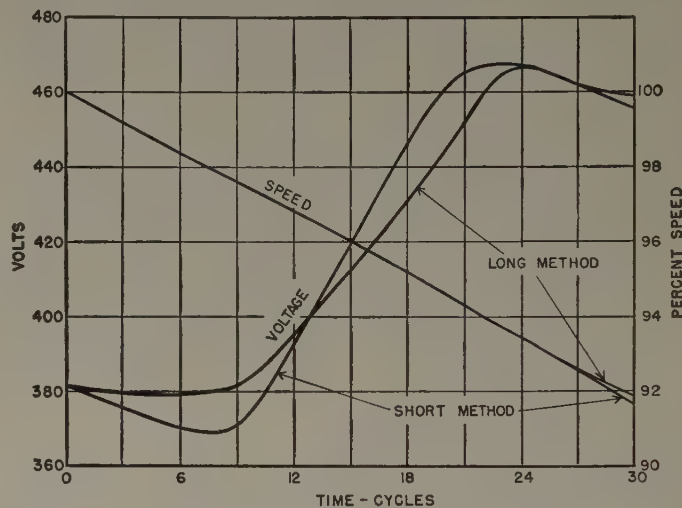

Figure 2. Main exciter voltage and speed as functions of time after the beginning of the fault

The motor-driven exciter offers definite advantages of reliability, simplicity of design, independent maintenance, and freedom from vibration as compared to conventional directly connected exciters.

This study shows that a 300-kw motor-driven exciter set with a response of 0.8, a ceiling voltage of 500 volts, and an H constant of 10.0 will furnish satisfactory excitation for all foreseeable conditions at the Elrama Station of the Duquesne Light Company. Under these conditions the exciter set is equivalent to a directly connected exciter since the response is at least 0.5 and the ceiling voltage is at least 120 per cent at the minimum speed reached. The set is driven by a 450-horsepower motor with a pull-out torque of 5.5 times rated full-load torque. The motor is designed so that maximum torque occurs at a higher slip than is normal for a motor of this rating so that there will be adequate torque margin at 90-per-cent speed with maximum exciter output.

A simplified method of calculation has been developed which will reduce greatly the effort necessary in future applications of motor-driven exciters.

Digest of paper 52-33, "Selection of Characteristics for Turbine-Generator Motor-Driven Exciters," recommended by the AIEE Committee on Power Generation and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Counting Chains, Codes, and Translations in Dial Pulse Register Circuits

R. M. M. OBERMAN

Automatic telephone systems require some means for counting the pulses of the dialed number. This article presents a logical review of some of the systems used with the object of leading to the ideal solution of the least possible number of relays and contacts operating in a clear registration code.

TRANSPORT OF SPEECH is the main object of telephony. The speech is transmitted via electrical ways, that is, the subscriber's lines, which are numbered systematically to admit a simple interconnection of those lines. When this interconnection is performed by means of automatic switching equipment, it is necessary to introduce a counting system which can be handled by the subscribers. The subscriber's set therefore is provided with the dial to operate the counting system in the automatic exchange. The dial interrupts the subscriber's line loop as many times as indicated by the digits of the dialed number. The number of the current interruptions of each series is counted and the automatic equipment is positioned accordingly.

This article will deal with the counting of series of dial pulses by means of relay chains. It is the object to give a logical review of some types of counting chains, leading to more systematic solutions and their use in dial pulse register circuits. It is necessary to count up to ten pulses. The use of all possible operating conditions of the relays of the counting chain leads to rather complicated and unsystematic diagrams with an inconveniently arranged sequence of the operating combinations. Counting chains of this type are practically of no importance for telephone switching systems.

The way generally used to build up counting chains is to connect in series a number of counting pairs of relays. This leads to two principally different types of counting chains.

HOMOGENEOUS LINEAR RELAY COUNTING CHAINS

THE BIG PROBLEM of designing counting chains is to find the solution using the least possible number of relays and contacts having a clear registration code. This code is of great importance because a clear code facilitates the design of the telephone switching system and admits easy maintenance and fault location. The practical solution of this problem will be found between the two extremes: that is, a relay chain using ten pairs of relays and a chain using all possible operating conditions of five relays. There will be no single solution but a number of solutions according to the requirements of the switching system in which the counting chain will be applied and the construction of the relays of the system.

Counting chains built up of sections with equal diagrams are called homogeneous. These chains are linear when no combinations of the operating conditions of the sections or relay pairs are used, or when these combinations are limited to a double use of the chain. The principle of a counting chain of this type, for many years used in the Bell *7A* Rotary System,[1] is shown in Figure 1. This chain consists of ten pairs of relays (six pairs shown), each releasing the preceding pair when being operated. After ten pulses only the tenth relay pair remains operated. This counting chain produces an entirely systematic but expensive registration in a 1-out-of-10 code on groups of 10 register relays per digit.

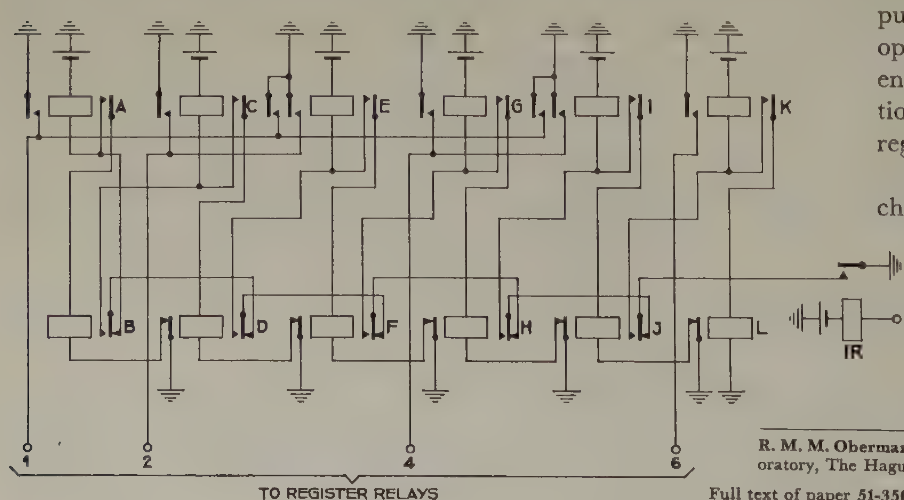

Figure 1. A homogeneous linear counting chain

It may be obvious that a linear counting chain with ten pairs of relays and ten register relays per digit offers no practical solution of the problem. A very good attack in solving this problem was made in the *7A2* Bell Rotary System (Bell Telephone Manufacturing Company, Ant-

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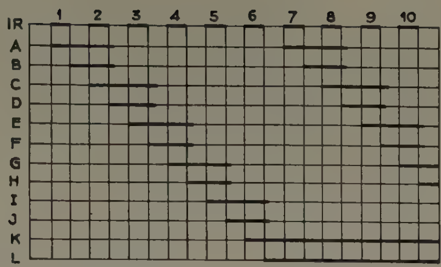
Full text of paper 51-350, "Relay Counting Chains, Codes, and Translations in Dial Pulse Register Circuits," recommended by the AIEE Committee on Communications Switching Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cleveland, Ohio, October 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, part II, 1951.

Figure 2. Relay action sequence of Figure 1



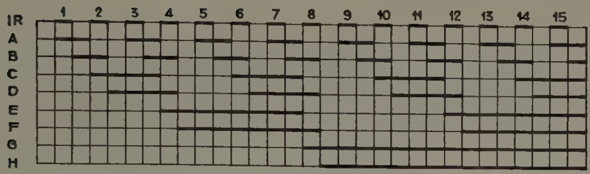


Figure 3. General relay action sequence of a binary counting chain

werp, Belgium) by making a double use of the first four pairs of a relay chain of six pairs as is shown in Figure 1. As may be seen in the sequence diagram of Figure 2, the counting chain of Figure 1 counts as follows. Relay *A* is magnetized by the first pulse on the pulse relay *IR*, relay *B* is magnetized in series with relay *A* in the pause after the first pulse, and so on. The sixth pulse magnetizes relay *K*, and relay *L* is magnetized in series with relay *K* in the pause after the sixth pulse. The second relay of each pair breaks with its left contact the holding circuit of the preceding pair. Relay pair *I/J* releases in the pause after the sixth pulse. This again connects the pulse contact to the first relay pair. Relay pair *K/L* remains operated. The seventh pulse now operates pair *A/B* and so on till the tenth pulse operates pair *G/H*.

In this system the digits are not registered on groups of six relays, but on groups of four relays, which is the minimum possible number. The relays of such a group have the systematic values of 1, 2, 4, and 6 respectively. The sum of the values of the operated relays of a register groups represents the received digit.

HOMOGENEOUS BINARY COUNTING CHAINS

Counting chains using all possible operating conditions of the relay pairs are called binary. All counting chains of this type show a relay action sequence as is given in Figure 3. A chain of four pairs of relays counts up to 15 pulses. The diagram of a very useful chain is shown in Figure 4. Relay *A* is operated on the first pulse, relay *B* is operated in series with relay *A* in the pause after the first pulse. The second pulse closes a holding circuit for a second winding of relay *B* and operates relay *C*. The left contact of relay *C* breaks the holding circuit of relay *A* and the first winding of relay *B*. Relay *A* releases. Relay *B* remains operated via the second winding as long as the contact of the pulse relay *IR* is closed on the second pulse. Relay *D* is operated in series with relay *C* in the pause after the second pulse when relay *B* also releases. After two pulses relays *C* and *D* are operated and relays *A* and *B* are then nonoperated. The pulse lead is again connected to the first pair of relays. Relay pair *A/B* is reoperated on the third pulse and pulse pause. This connects the pulse lead to the third pair of relays *E/F*. The fourth pulse operates this pair and releases pairs *A/B* and *C/D*, and so on. All possible operating combinations of the pairs are passed systematically. The number of received pulses can be counted easily by giving the values 1, 2, 4, and 8 to the pairs. The sum of the values of the operated pairs represents the received number of pulses.

The counting chain of Figure 4 has one limitation in its design. The number of directly interconnected counting pairs is limited to about five or six, according to the type of relays used, because the locking windings of relays *B*, *C*, and *D* are connected in parallel to the operating winding of relay *G*. When relay *H* is connected in series with relay *G* in the pause after the eighth pulse, the locking windings of relays *B*, *C*, and *D* remain connected in parallel to the winding of relay *G* during a short time. This reduces the holding current of relay *G*, which may go so far with an unsuitable design that it releases.

The advantage of the binary counting chain in register circuits is that no code translation is necessary. The received combination of the four pairs of the counting chain can be transferred to groups of four register relays without change in code. The chain itself is very simple, using only one transfer and one make contact on each relay, or in total ten springs per pair. The linear counting chain of Figure 1 has 11 springs on pair *E/F* as a maximum.

The binary counting chain may be adapted easily to the 1, 2, 4, 6 code of the Bell Rotary Systems. The pulse contact then is connected with the fourth relay pair having the value 6 when the sixth pulse will be received. This 1,2,4,6 code was born in the time when no practical binary counting chains existed, but now this code seems to be overtaken by the binary code.

HOMOGENEOUS SINGLE RELAY COUNTING CHAINS

The diagram of a single relay counting chain is shown in Figure 5. The relay action sequence of this chain

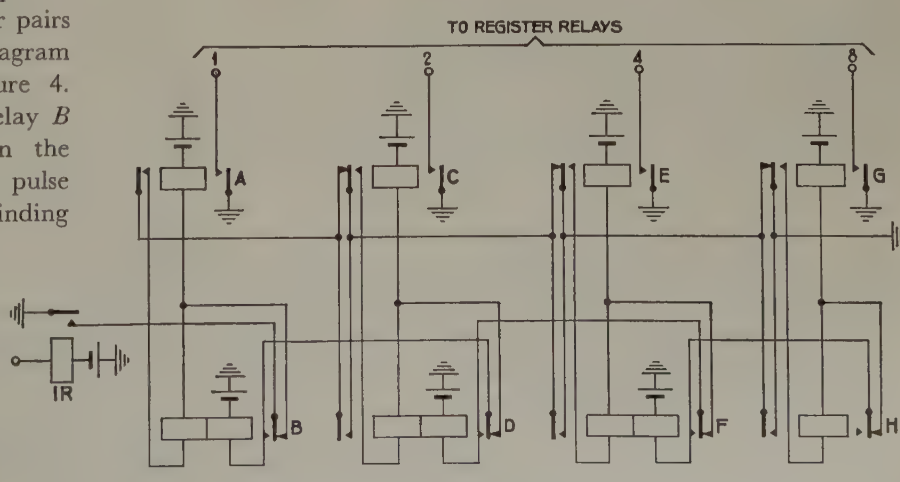


Figure 4. A binary counting chain

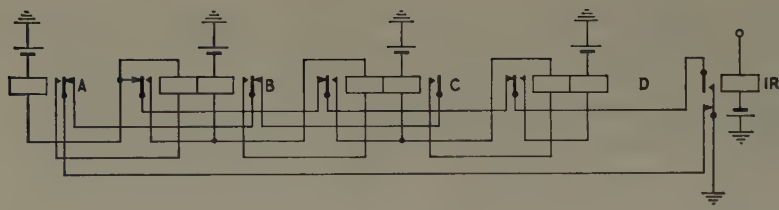


Figure 5 (left). A single relay counting chain

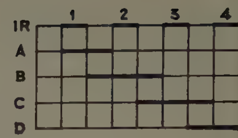


Figure 6 (right). Relay action sequence of a single relay counting chain

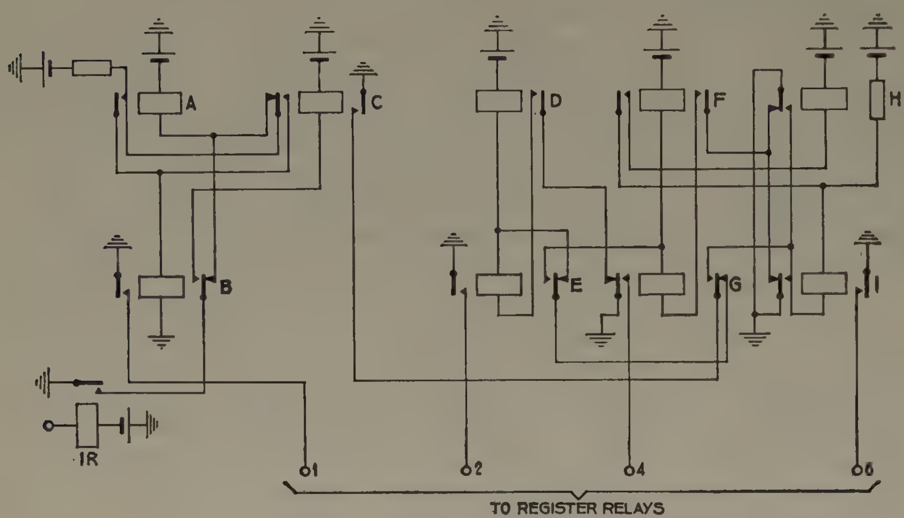


Figure 7 (left). Nonhomogeneous counting chain in 1, 2, 4, 6 code

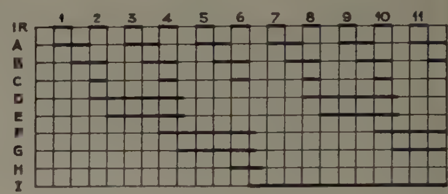


Figure 8. Relay action sequence of Figure 7

is given in Figure 6. The chain is controlled by means of a continuity transfer contact of the pulse relay *IR*. The circuit of relay *A* is closed on the first pulse via the break sides of the left transfer contacts of the relays. In the pause after the first pulse relay *B* is operated in series with relay *A* via a second pulse wire leading through the right transfer contacts of the relays. The first pulse wire via the left transfer contacts is connected by the left transfer contact of relay *B* to the second section of the diagram consisting of a second winding of relay *B* and a first winding of relay *C*. The second pulse closes the circuit of the first wire and breaks that of the second pulse wire. This locks relay *B* on the second winding and breaks the circuit of the winding of relay *A* and the first winding of relay *B*. Relay *A* releases. Relay *C* is operated via a first winding and the second pulse wire in series with the second winding of relay *B*. The left transfer contact of relay *C* connects the first pulse wire to the third section of the diagram, and so on. A counting chain of this type needs $n+1$ relays for n pulses.

A more systematic use of this counting chain can be made by reversing the position of the pulse contact. Relay *A* is already operated in the rest condition of the counting chain, relay *B* is the only one operated after the first pulse, relay *C* is the only one after the second pulse, and so on.

NONHOMOGENEOUS COUNTING CHAINS

It is possible to design counting chains with different types of diagrams of the sections. The diagram of Figure 7 shows a chain with a binary type start section followed by a doubly used linear chain. Counting chains of this type are called nonhomogeneous.

The counting chain of Figure 7 is designed under the requirements that relays with one winding and two transfer contacts only may be used, and that it can co-operate with groups of four register relays with the 1,2,4,6 operating code. This problem may be solved, to some extent satisfactorily, by means of a single stage of a binary counting chain (relays *A*, *B*, and *C*) followed by a doubly used linear counting chain consisting of three sections (*D/E*, *F/G*, and *H/I*). The relay action sequence of this diagram is shown in Figure 8. The binary section (*A*, *B*, and *C*) is working under the direct control of the contact of the pulse relay *IR*; the linear sections are working under the control of the right make contact of relay *C*. On the first pulse relay *IR* closes an operating circuit for relay *A*. Relay *B* is magnetized in series with relay *A* in the pause after the first pulse. The second pulse operates relay *C* via the right transfer contact of relay *B*. The break side of the left transfer contact of relay *A* then releases relay *A* and closes temporarily a holding circuit for relay *B*. Relay *C* and consequently relay *B* are released in the pause after the second pulse, and so on.

The linear sections *D/E*, *F/G*, and *H/I* operate in the same way as has been described for Figure 1. The recycling, which is not so simple, is performed by means of the left contacts of relays *F*, *H*, and *I*, as may follow from the relay action sequence diagram of Figure 8.

The use of two different counting principles in one counting chain may be regarded as an important disadvantage especially for maintenance and fault location. The number of relays of the diagram of Figure 7 can be reduced to six in a rather appreciable diagram, when the linear counting chain of Figure 5 is used instead of that of Figure 1. That diagram does not fulfill the requirements just given.

A nonhomogeneous counting chain, which has drawn much attention and which seems to be applied on a big scale, is shown in Figure 9.[2] The relay action sequence is given in Figure 10. The counting chain consists of a single binary section with three relays (L_3, L_4, and L_5), followed by a doubly used linear chain (P_1 to P_6) and an auxiliary relay P_{6a}. These linear sections count as follows:

P_1, P_2, P_3, P_4, P_5, P_5+P_6, P_1+P_6, P_2+P_6, P_3+P_6, P_4+P_6. The relays of the binary working start section only play an auxiliary role. The operating conditions of the relays of the linear sections are transferred to groups of five register relays. The receiving code is translated meanwhile in another code in which two relays always are operated, the 2-out-of-5 code. The five register relays of the group have the values 0 (zero), 1, 2, 4, and 7. The sum of the values of the operated relays equals the received number, except for 0 (ten), which is 4+7.

The contact of the pulse relay *IR* operates relay L_3 on the first pulse. In the pause after the first pulse relay L_5 is magnetized on a first winding in series with relay L_3. The second pulse operates relay L_4 and locks relay L_5 on a second winding. The right contact of relay L_4 breaks the circuit of relay L_3 and the first winding of relay L_5. Relay L_3 then releases. Relays L_4 and L_5 are released in the pause after the second pulse. The operating cycle starts again on the third pulse.

The right transfer contact of relay L_5 controls the linear chain with relays P_1 up to P_6. Relay P_1 is operated in the pause after the first pulse via the make side of the right transfer contact of relay L_5 and a chain of break contacts of relays P_4, P_2, P_3, and P_5. Relay P_1 locks itself via a make contact and a chain of break sides of the continuity transfer contacts of relays P_2 up to P_5. Relay P_2 operates in the pause after the second pulse via the break side of the right transfer contact of relay L_5 and a make contact of relay P_1. Relay P_1 locks itself via the make side of its continuity transfer contact, which breaks the holding circuit of relay P_1 and so on. Relay P_6 operates in the pause after the sixth pulse. The upper contact of this relay closes the pulse wire to relay P_1, which is again operated in the pause after the seventh pulse. Relay P_1 now releases relay P_5.

HOMOGENEOUS CHAINS FOR 2-OUT-OF-5 CODE

The counting chain of Figure 9 is not designed logically because of the nonhomogeneous character and the code translation. Two questions arise from this: is it possible to design a homogeneous relay chain counting in the same code as the counting chain of Figure 9; and is it possible to design a homogeneous counting chain already counting in the given 2-out-of-5 code, thus approximating the logical counting ideal?

A counting chain counting in the same code as the *L* and *P* relays of Figure 9 readily may be designed by means of the linear principle given in Figure 5. The diagram is given in Figure 11, and the relay action sequence in Figure 12. As this chain counts exactly in the same code, the contacts translating the receiving code into the register code are omitted in the diagram. The disadvantage of the continuity transfer pulse contact is probably of no importance in this case. After the aforesaid about the diagram of Figure 5, the working of the chain of Figure 11 may be clear from the relay action sequence shown in Figure 12. The chain consists of six counting relays P_1 up to P_6, having the values 1 to 6 respectively, and an auxiliary relay P_0, which plays a role in the starting and the recycling of the chain. The balance between the counting parts of both diagrams results in nine relays with 53 springs and 31 contacts (Figure 9) against seven relays with 39 springs and 25 contacts (Figure 11), which is favorable for the logical solution of the problem. The

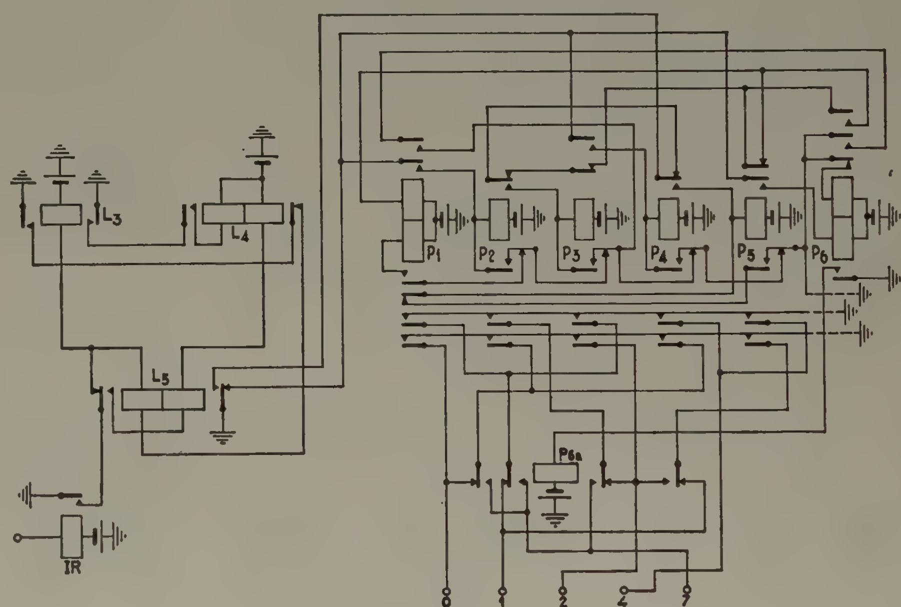


Figure 9 (above). Nonhomogeneous 2-out-of-5 code counting chain

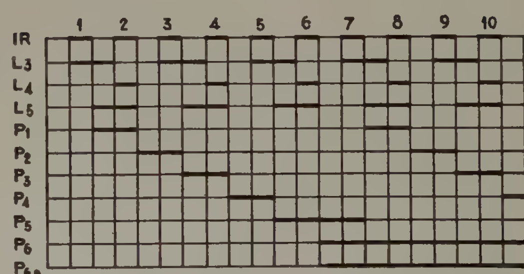


Figure 10 (right). Relay action sequence of Figure 9

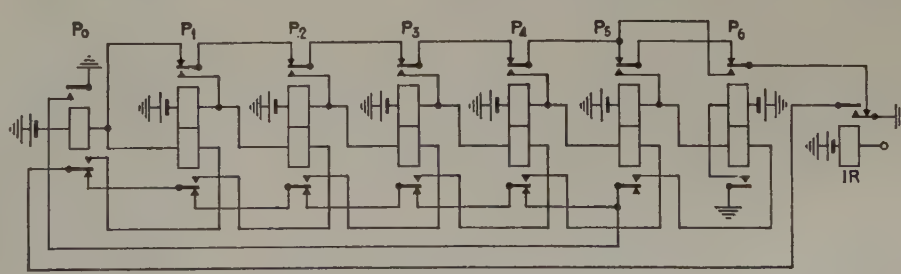


Figure 11. Homogeneous linear counting chain analogous to Figure 9

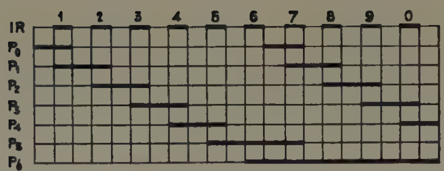
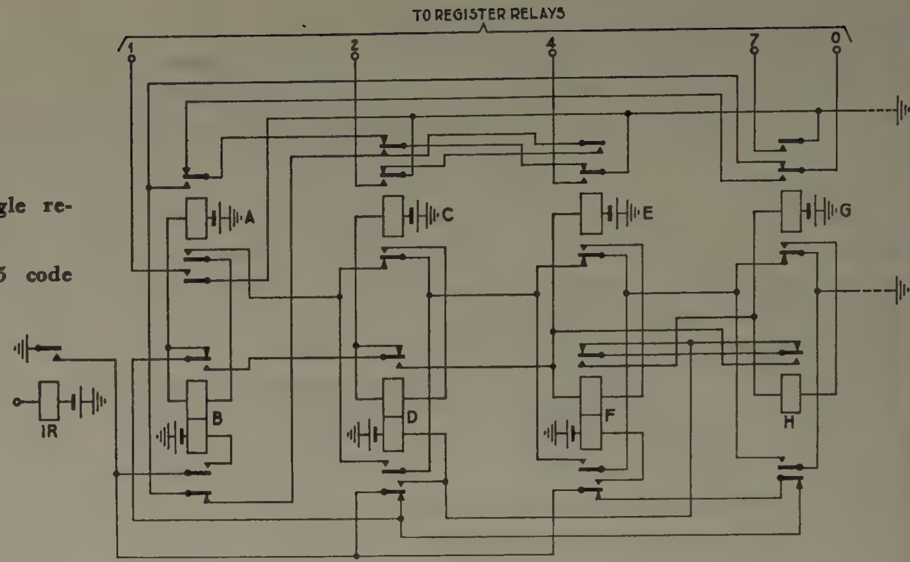


Figure 12. Relay action sequence for single relay counting chain in 2-out-of-5 code

Figure 13 (right). Homogeneous 2-out-of-5 code counting chain



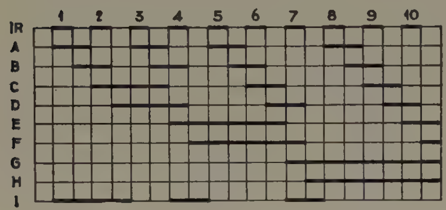


Figure 14. Relay action sequence of Figure 13

diagram of Figure 11, moreover, offers the advantage that all seven relays can be made equal without difficulty.

The counting chain of Figure 11 gives no satisfaction from the viewpoint of the still necessary code translation. An investigation of the 2-out-of-5 code used shows that it comes close to the code of the binary counting chains. The difference is principally incorporated in the fact that the relay pair with the values 8 in the binary code has a value of only 7 in the 2-out-of-5 code. In the groups of register relays a fifth with the value 0 (zero) has been added, which has no meaning in the problem of the counting chain. This 0 unit has to be produced artificially.

A relay counting chain in the 1,2,4,7 code, derived from the binary counting chain of Figure 4, is shown in Figure 13; the relay action sequence is given in Figure 14. The chain works binary up to six pulses exactly in the way described for Figure 4. The pulse wire is switched over to the fourth relay pair *G/H*. The seventh pulse operates this pair. After that the first three relay pairs work as a linear counting chain, the first two pairs being operated via the normal pulse wire and the third pair on the tenth pulse via the auxiliary control wire via the upper transfer contacts of relays *F* and *H*. In this way the relay counting chain works in the 1,2,4,6 code. This code can be transferred without any translation to groups of register relays by means of a single make contact of each relay pair. The zero wire, which has no meaning in the case of a pulse receiving relay counting chain, is produced by means of a simple contact circuit, which is shown in Figure 13. This counting chain has not the least number of relays, but has the least number of springs and contacts.

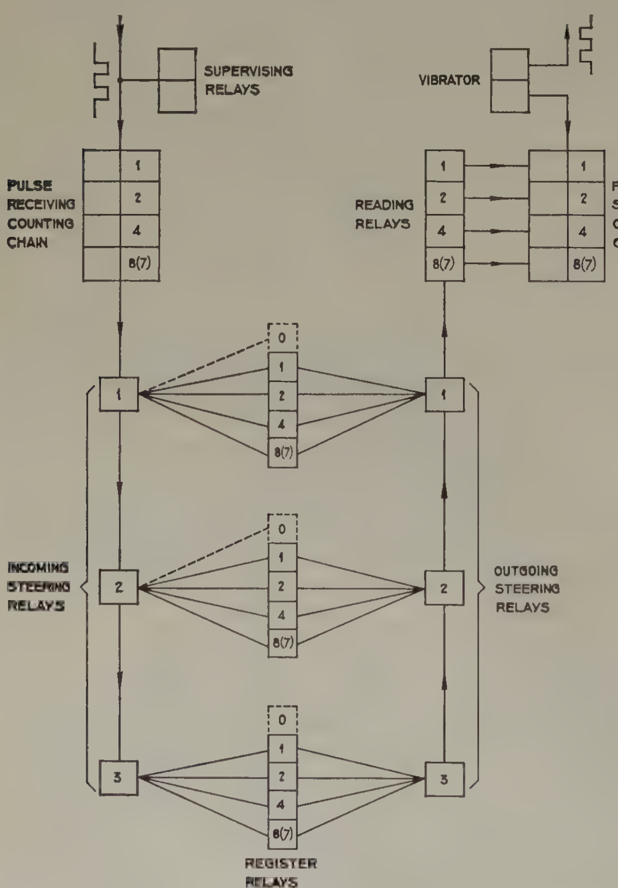


Figure 15. General diagram of a pulse register

CONCLUSION

No attention was paid in the preceding paragraphs to the switching systems in which the register circuits have to be applied. These systems are so large in number and differ so much that it is impossible within the limits of this article to describe a number of applications of the developed principles. The reader skilled in the art of switching will have enough information to apply the principles given. The principles are of a general character, which may follow from the self-explaining diagram of Figure 15, in which symbolically a complete pulse register is shown having no code translation. The receiving counting chain is shown on one side, the sending counting chain on the other side, the register relays between both counting chains, and the registration code going straight through.

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Out-of-Phase Voltage Effects in Circuit Breakers

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THE POSSIBILITY THAT transmission-line circuit breakers may be subjected to as much as double normal line-to-ground voltage if opened during a system disturbance when sections on either side of the circuit breaker are out-of-phase has been recognized by manufacturers and operating personnel for a long time. However, only a few isolated cases of trouble have been traced to this exceptional circuit-breaker duty, and therefore it has not been felt justifiable in circuit-breaker specifications to insist on proved ability to handle double voltage interruptions. Experience indicates that many circuit breakers have struggled through out-of-phase operations by continuing to arc until separating parts of the system have swung sufficiently in phase again to permit interruption.

Nevertheless, there is evidence that this problem is becoming of greater importance because of the tremendous increase in power concentration resulting from the integration of large generating centers into gigantic interconnected power pools. These conditions justify more detailed study of out-of-phase switching phenomena and their effects on high-voltage circuit breakers.

This article comprises an analytic study of dynamic voltages to be expected at the terminals of a tie-line circuit breaker during the separation of two parts of a system 180 degrees out-of-phase. Transient voltage crests have been investigated on the analogue computer for a typical system under faulted and unfaulted conditions and the results compared with oscillographic records obtained on an actual power system. Finally, high-power laboratory data obtained on modern high-voltage circuit breakers opening fault currents at twice normal voltage and higher are evaluated in the light of the maximum possible duty indicated by the analytical study.

The study showed that crest dynamic voltages across the circuit-breaker poles during completely out-of-phase conditions on solidly grounded systems could be as high as 260 per cent of normal line-to-neutral crest voltage. The results of the analogue computer study indicated transient overshooting of as much as 60 per cent above the dynamic voltage crest. Under the most unfavorable out-of-phase switching conditions within the limits of effective grounding ($R_0/X_1<1$ and $X_0/X_1<3$), the peak of the transient voltage theoretically could reach 2.6×1.6 or a little over 4 times normal line-to-ground crest voltage. On a 230-kv system this amplitude would be $230/\sqrt{3}\times\sqrt{2}\times4.16=780$ kv, which exceeds by 30 per cent the crest voltage of the 425-kv 1-minute insulation test applied across the fully open contacts of circuit breakers for use on 230-kv systems with effectively grounded neutrals. This emphasizes the extreme duty that is indicated by these calculations.

Other results of the analogue computer study are as follows: 1. the most severe transient overvoltages from the standpoint of circuit-breaker duty occur when the tie circuit breaker is located at the center of the tie line; 2. the presence of permanent faults on a system under out-of-phase conditions does not increase the magnitude of the maximum recovery voltages on the circuit breakers' separating parts of the system.

The figures obtained from the computer study were checked against the results of a recovery voltage study made by the Bonneville Power Administration at their Midway switching station. The recovery voltages which occurred when switching a grounded 3-phase fault were measured on the assumption that the actual recovery voltages under completely out-of-phase conditions would be approximately twice the measured values. The analogue computer study proved this assumption to be essentially correct.

At the present time, there are no test specifications for circuit breakers covering interrupting ability under out-of-phase voltage conditions. If the most unfavorable theoretical conditions indicated by this study were taken as the basis of a specification, the cost of suitable circuit breakers probably would be increased considerably more than warranted by difficulties now experienced with present equipment. However, a reasonable test might be the interruption of moderate short-circuit currents up to 25 per cent of rating at twice normal line-to-ground voltage. The natural frequency of the recovery voltage transient might be as low as 300 cycles, with no more external circuit damping than enough to limit the overshooting to approximately 25 per cent of normal crest. Additional damping could be provided by resistors in the circuit breaker as part of the contact assembly.

A number of modern high-voltage circuit breakers have been tested at double voltage and higher with satisfactory results. For example, on a 10,000-megavolt-ampere 230-kv circuit breaker, tests at 2,000 amperes were carried as high as 360 kv across a single-pole unit, or 2.7 times normal line-to-ground voltage, without damage to the interrupters. The maximum crest voltage withstood on the recovery voltage transient was about 560 kv. Although damping in the laboratory circuit limited the overshooting to approximately 20 per cent, the frequency oscillation was quite high, about 3,000 cycles, as compared to the 300- to 400-cycle oscillation encountered in the field.

Digest of paper **52-16**, "Out-of-Phase Switching Voltages and Their Effect on High-Voltage Circuit Breaker Performance," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Low-Energy Measurement Problems in Cathodic Protection

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Some elementary methods of obtaining metal-to-soil potential measurements are analyzed for the purpose of developing rugged yet sufficiently accurate field measuring equipment. These potentials often must be known for cathodic protection work.

IN CORROSION AND cathodic protection work, it frequently is found necessary to measure what is known as the structure-to-soil potential. This voltage normally is thought of as the voltage existing between the underground metal and the soil solution directly adjacent, and consists almost entirely of electrochemical film potentials at the surface of the metal. There are a number of laboratory methods available to measure such potentials, but measurements in the field with more rugged, and less accurate, equipment is a prime requisite.

This article concerns some of the elementary considerations of field measurement methods of obtaining metal-to-soil potentials. Figure 1*A* shows a simple example of an underground pipe line, where *P* designates the metal structure, *V* a voltmeter, and *C* is an electrode for contacting the soil. The equivalent electric circuit is shown in Figure 1*B*, where R_{V1} is the resistance of the voltmeter, *R* the resistance of the remainder of the circuit, including the soil resistance which is assumed here to be a constant, E_{12} is the voltage to be measured, and E_{34} is the voltage developed in the soil contacting electrode. (For purposes of writing circuit equations, it will be assumed that the reference voltage polarity mark will always be on the first subscript of all double-subscript voltages.)

To simplify the analysis, it will be assumed further that the soil portion of the resistance *R* has no current through it except the current in the measuring circuit. In other words, no voltages due to external impressed currents will be assumed.

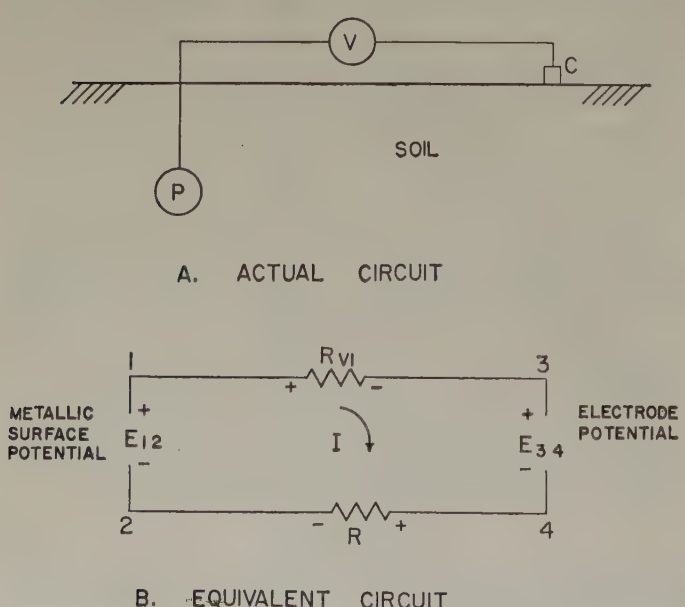


Figure 1. The basic potential measuring circuit

From the equivalent circuit diagram, Figure 1*B*, the voltmeter reads

$$V_{13}=IR_{V1}=-E_{34}-IR+E_{12} \tag{1}$$

Obviously this is not the value E_{12} alone, which is what is desired. Even if the voltmeter draws zero current, the potential E_{34} of the electrode at *C* is still included in the measurement. Thus the question arises at once as to what should be done to determine E_{34}.

Some engineers have assumed that they could use a contacting material at *C* that was of the same composition as the underground metal at *P*, or of some other foreign composition. This assumption is usually a poor one, as E_{34} is then a function of the current drawn by the voltmeter, and consists of nonlinear surface polarization effects. A better solution has been to use a chemical electrode such as the saturated calomel half cell, or the saturated copper-sulphate half cell. These chemical electrodes have potentials which are relatively stable under normal metering currents, and although E_{34} is not eliminated it is at least a known value.

The calomel electrode system is relatively cumbersome and fragile, hence the corrosion engineers in the field have preferred the copper-sulphate half cell for most field measurements. This introduces a value of $E_{34}=0.50$ volt, approximately.

This introduction of the known voltage, E_{34}, now solves the problem of determining E_{12}, providing that no current is drawn by the voltmeter. However, this requires a potentiometer-type or a vacuum-tube voltmeter even to approach the condition of zero current. Both instruments are expensive and may even be hard to hold in calibration under field use. An alternate method would be to use a more rugged voltmeter of lower resistance and to correct for the voltage drop in the circuit in some manner. The following analysis gives both exact and approximate methods of accomplishing this.

Equation 1 can be rewritten as

$$(E_{12}-E_{34})=I(R_{V1}+R)$$

Full text of a conference paper recommended by the AIEE Committee on Chemical, Electrochemical, and Electrothermal Applications and presented at the AIEE Fall General Meeting, Cleveland, Ohio, October 22–26, 1951.

H. N. Hayward and R. M. Wainwright are both with the University of Illinois, Urbana, Ill.

Then

$$\frac{V_{13}}{E_{12}-E_{34}}=\frac{IR_{V1}}{I(R_{V1}+R)}$$

and

$$V_{13}=\frac{(E_{12}-E_{34})R_{V1}}{R_{V1}+R}$$

Now suppose another voltmeter (or the same one) of lower resistance is used. The resistance of the original voltmeter can be reduced by connecting a resistor R_p in parallel with the voltmeter, as shown in Figure 2. The second voltmeter reading is

$$V_{13}'=IR_{V2}=\frac{(E_{12}-E_{34})R_{V2}}{R_{V2}+R}$$

$$\frac{V_{13}}{V_{13}'}=\frac{\dfrac{R_{V1}}{R_{V1}+R}}{\dfrac{R_{V2}}{R_{V2}+R}}=\frac{R_{V1}(R_{V2}+R)}{R_{V2}(R_{V1}+R)}=\frac{R_{V1}R_{V2}+R_{V1}R}{R_{V1}R_{V2}+R_{V2}R}$$

V_{13}, V_{13}', R_{V1}, and R_{V2} are known; the only unknown is R.

$$V_{13}(R_{V1}R_{V2}+R_{V2}R)=V_{13}'(R_{V1}R_{V2}+R_{V1}R)$$
$$V_{13}R_{V1}R_{V2}+V_{13}R_{V2}R=V_{13}'R_{V1}R_{V2}+V_{13}'R_{V1}R$$

R_{V2} is less than R_{V1}, so V_{13}' will be smaller than V_{13}.

$$R_{V1}R_{V2}(V_{13}-V_{13}')=R(V_{13}'R_{V1}-V_{13}R_{V2})$$

$$R=\frac{R_{V1}R_{V2}(V_{13}-V_{13}')}{V_{13}'R_{V1}-V_{13}R_{V2}} \quad (2)$$

Since

$$\frac{E_{12}-E_{34}}{V_{13}}=\frac{R_{V1}+R}{R_{V1}}$$

and

$$\frac{E_{12}-E_{34}}{V_{13}'}=\frac{R_{V2}+R}{R_{V2}}$$

$$E_{12}-E_{34}=\frac{V_{13}(R_{V1}+R)}{R_{V1}}$$

Substituting the value for R in this equation

$$E_{12}-E_{34}=\frac{V_{13}\left(R_{V1}+\dfrac{R_{V1}R_{V2}(V_{13}-V_{13}')}{V_{13}'R_{V1}-V_{13}R_{V2}}\right)}{R_{V1}}$$

$$=V_{13}\left[\frac{R_{V1}(V_{13}'R_{V1}-V_{13}R_{V2})+R_{V1}R_{V2}(V_{13}-V_{13}')}{R_{V1}(V_{13}'R_{V1}-V_{13}R_{V2})}\right]$$

$$=V_{13}\left[\frac{(V_{13}'R_{V1}-V_{13}R_{V2})+R_{V2}(V_{13}-V_{13}')}{V_{13}'R_{V1}-V_{13}R_{V2}}\right]$$

$$=V_{13}\left[1+\frac{R_{V2}(V_{13}-V_{13}')}{V_{13}'R_{V1}-V_{13}R_{V2}}\right] \quad (3)$$

From this analysis, equation 2 shows that the unknown circuit resistance R is capable of being determined from the two sets of voltmeter readings and a knowledge of the two values of instrument resistance. This, however, is not a recommended method of calculating R because of the inherent inaccuracy in the voltage difference term where the two voltages involved are of nearly the same magnitude. The expression for R here is an intermediate step in the development of equation 3 but does provide a qualitative means of evaluating R without any additional

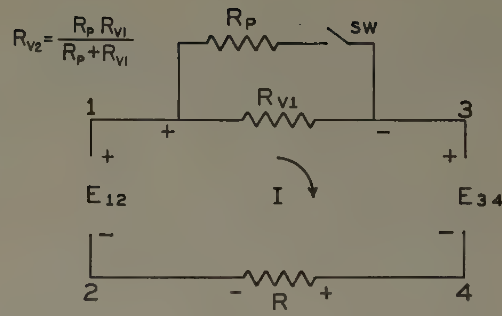


Figure 2. Measuring circuit modified to reduce the voltmeter resistance

measurements. But R could be determined more conveniently for a particular voltmeter resistance from a curve based on ratios given in Table I. It will be noted that as the ratio R/R_{V1} increases, the ratio $(V_{13}-V_{13}')/V_{13}$ also increases, although the two ratios do not vary proportionally. $V_{13}-V_{13}'$ is 4.5 per cent of V_{13} when $R/R_{V1}=0.05$ and increases further as R/R_{V1} becomes larger. Any method of calculating R from the voltmeter readings will include the difference between the readings in the calculation, so will become potentially more inaccurate as the difference becomes smaller.

Equation 3 shows that the true open-circuit voltage, $E_{12}-E_{34}$, consists of the first voltmeter reading, V_{13}, plus a correction term. It can be shown that the higher the value of R_{V1} with respect to R, the more nearly V_{13} is the true open-circuit voltage. Figure 3, curve B, shows the relation of the voltmeter readings compared to the true open-circuit voltage, curve A, and with respect to various ratios of R_{V1} to R. Thus, when the lower resistance voltmeter is used, or when the first voltmeter is paralleled by a resistor, R_p, a still lower voltmeter reading results as shown by the curve. If R_p (see Figure 2) is chosen such that $R_{V2}=R_{V1}/2$, it can be shown that equation 3 reduces to

$$E_{12}-E_{34}=V_{13}\left[1+\frac{V_{13}-V_{13}'}{V_{13}'-(V_{13}-V_{13}')}\right] \quad (4)$$

Similarly, equation 2 reduces to

$$R=\frac{R_{V1}(V_{13}-V_{13}')}{V_{13}'-(V_{13}-V_{13}')} \quad (4A)$$

which simplifies the work of calculating the circuit resistance.

The correction term of this equation involves only the lower voltmeter reading and the difference between the readings, so the calculations will be simpler than those

Table I. Calculated Values for the 2-Voltmeter-Reading Method

Resistance Ratios R/R_{V1}	Resistance Ratios R_{V1}/R	Ratio of Voltage Difference to Higher Voltage Reading $(V_{13}-V_{13}')/V_{13}$	Voltages in Per Cent of Open-Circuit Voltage: Voltmeter Reading V_{13}	Voltmeter Reading $V_{13}'(R_{V2}=R_{V1}/2)$	Difference $V_{13}-V_{13}'$	Approximate Correction $V_{13}+(V_{13}-V_{13}')$	Per Cent Error Resulting from Use of Approximate Correction
0.001	1,000	0.0010	99.90	99.80	0.1	100.0	0
0.002	500	0.0020	99.80	99.60	0.2	100.00	0
0.005	200	0.0049	99.50	99.01	0.49	99.99	0.01
0.01	100	0.0098	99.01	98.04	0.97	99.98	0.03
0.02	50	0.0193	98.04	96.15	1.89	99.93	0.07
0.05	20	0.0454	95.24	90.91	4.33	99.57	0.43
0.1	10	0.0833	90.91	83.33	7.48	98.49	1.51
0.2	5	0.1428	83.33	71.43	11.9	95.23	4.77
0.5	2	0.2500	66.67	50.00	16.67	83.34	16.66
1	1	0.3333	50.00	33.33	16.67	66.67	33.33

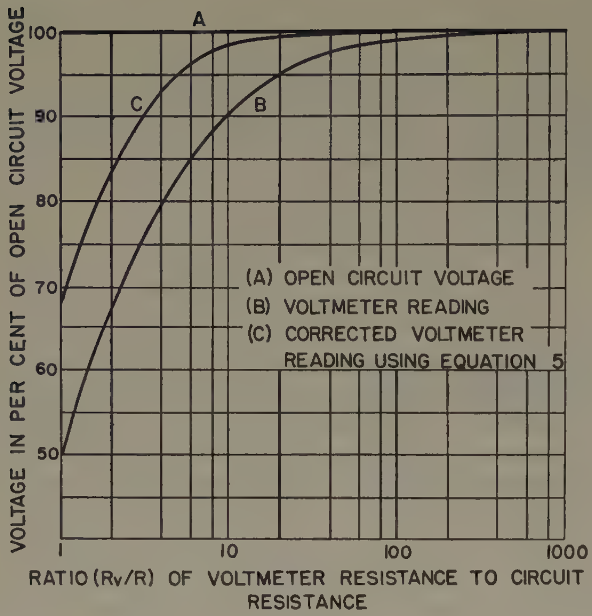


Figure 3. Effect of ratio of voltmeter resistance to circuit resistance on reading of voltmeter

based on equation 3. However, each correction still involves four calculations, so that the advantage of using a simple rugged instrument for making the measurements may be nullified by the work involved in making the corrections. The possibility of simplifying the process of making the corrections and still giving a result that approximates the open circuit voltage will next be considered.

If $(E_{12}-E_{34})-V_{13}=V_{13}-V_{13}'$, then $(E_{12}-E_{34})=V_{13}+(V_{13}-V_{13}')$. Only two calculations would be necessary in making the correction, a difference and a sum. The conditions under which such a method of making corrections may be used may be determined readily.

$$V_{13}=\frac{(E_{12}-E_{34})R_{V1}}{R_{V1}+R}$$

and

$$V_{13}'=\frac{(E_{12}-E_{34})R_{V2}}{R_{V2}+R}$$

$$(E_{12}-E_{34})-V_{13}=(E_{12}-E_{34})-\frac{(E_{12}-E_{34})R_{V1}}{R_{V1}+R}=$$

$$(E_{12}-E_{34})\left(1-\frac{R_{V1}}{R_{V1}+R}\right)=(E_{12}-E_{34})\left(\frac{R}{R_{V1}+R}\right)$$

Also

$$V_{13}-V_{13}'=\frac{(E_{12}-E_{34})R_{V1}}{R_{V1}+R}-\frac{(E_{12}-E_{34})R_{V2}}{R_{V2}+R}$$

$$=(E_{12}-E_{34})\left(\frac{R_{V1}}{R_{V1}+R}-\frac{R_{V2}}{R_{V2}+R}\right)$$

$$=(E_{12}-E_{34})\left[\frac{R(R_{V1}-R_{V2})}{(R_{V1}+R)(R_{V2}+R)}\right]$$

Then

$$\frac{R}{R_{V1}+R}=\frac{R(R_{V1}-R_{V2})}{(R_{V1}+R)(R_{V2}+R)}$$

$$R_{V2}+R=R_{V1}-R_{V2}$$

and

$$R_{V2}=\frac{R_{V1}-R}{2}$$

Thus if the lower value of voltmeter resistance is always equal to one-half the difference between the higher value of voltmeter resistance and the circuit resistance, the difference between the two voltmeter readings added to the higher reading will equal the open-circuit voltage. But the circuit resistance R will not be the same for any two readings except by chance, so R_{V2} cannot remain constant without introducing some inaccuracy in the calculated value of the open-circuit voltage. However, R_{V1} usually will be much larger than R so the requirement that $R_{V2}=(R_{V1}-R)/2$ will be approximately satisfied in most instances if $R_{V2}=R_{V1}/2$. The results of calculating the value of $(E_{12}-E_{34})$ by adding $(V_{13}-V_{13}')$ to V_{13} for a number of values of the ratio R_{V1}/R are shown in Table I. All the values of $(E_{12}-E_{34})$ so calculated are small. The differences for large values of the ratio R_{V1}/R are negligible. When $R_{V1}/R=20$, the difference is less than 0.5 per cent. It becomes about 1.5 per cent for $R_{V1}/R=10$ and increases rapidly as the value of R_{V1}/R becomes smaller than 10. Thus it can be seen that the approximate value of the open-circuit voltage can be calculated by adding the difference between the voltmeter readings to the higher reading, if $R_{V2}=R_{V1}/2$, except for small values of the ratio R_{V1}/R.

$$(E_{12}-E_{34})=V_{13}+(V_{13}-V_{13}') \text{ approximately} \tag{5}$$

Thus, a good approximation of the open-circuit voltage is obtained by adding the difference between the two voltmeter readings to the higher of the two readings. The higher voltmeter reading corrected by use of equation 5 is plotted as curve C in Figure 3. The tabulated results of calculations on which curves B and C are based are given in Table I. Once the range of values of R is determined, improved results from the use of the approximate equation might be obtained by making R_{V2} slightly less than $R_{V1}/2$.

A voltmeter for field use having two values of resistance could be constructed by incorporating the resistor R_p and the switch SW in the instrument case. Such an instrument might be made to have more than one range by using an appropriate range selector that would also change the value of R_p so the ratio R_p/R_{V1} would remain constant.

Methods similar to those discussed here for voltage measurements also may be applied in connection with current measurements, particularly in cathodic protection circuits utilizing magnesium anodes. By using an ammeter capable of introducing two values of known resistance in the circuit and taking readings for each of the two resistance values, the exact or approximate value of the current existing in the circuit before the ammeter is connected can be calculated. The circuit resistance also can be determined. Changing the resistance of the ammeter is more difficult than in the case of the voltmeter, because of the small value of the ammeter resistance. The total resistance added to the circuit by the connection of the ammeter is involved, not the resistance between the potential terminals of the ammeter shunt.

INSTITUTE ACTIVITIES

Three New Publications to Be Inaugurated by AIEE in July

Beginning in July 1952, the Institute will inaugurate three new publications bimonthly on an annual subscription basis to take the place of the present AIEE *Proceedings* which will be discontinued. The plan for the new publications was approved by the Board of Directors at its meeting on January 24. The publications are tentatively titled as follows:

Electronics and Communication
Applications and Industry
Power Apparatus and Systems

Each publication will be issued every other month. *Electronics and Communication* and *Applications and Industry* will be issued in the same months. *Power Apparatus and Systems* will be issued on alternate months.

A listing of the subject matter to appear in each of the three new publications and the months of issue is given in Table I.

Member Subscriptions. Each member will have the option to elect to receive in consideration of payment of dues without additional charge one of the three bimonthly publications. Additional publications may be obtained by members at an annual subscription price of $2.50 each.

A subscription card will be sent to all members within the next few weeks and the placing of subscriptions should be deferred until that time.

Nonmember Subscriptions. Nonmembers may subscribe to any of the three publications on an advance annual subscription basis of $5.00 each (plus 50 cents extra for foreign postage payable in advance in New York exchange). A discount of 25 per cent will be allowed to college and public libraries. Publishers and subscription agencies may be allowed a discount of 15 per cent. Single copies may be obtained when available at $1.00 each.

For several years, the Publication Committee has had under study a plan for divisional publications to take the place of the present *Proceedings*. The need has been expressed for a fast publication in the field of electronics which would go to the members automatically. There is evidently considerable objection to filling out forms to obtain individual copies of papers.

A technical division publications questionnaire, from which there were 19,396 returns, indicated that $67^1/_2$ per cent of the members favored a plan of divisional publication as compared with 25 per cent who were in favor of the present *Proceedings*. A random analysis of those who had previously ordered *Proceedings*, when compared with their answers to the questionnaire, indicated that 57 per cent were in favor of the proposed divisional publications as compared with 40 per cent who favored the present *Proceedings*.

After consideration of the sources of supply of papers and the dates of availability, the Publication Committee decided that a series of three publications as outlined and issued every other month on an annual subscription basis would best meet the requirements of the membership.

When it is considered that the returns of the technical division publications questionnaire indicated that over 19,000 different members will make use of the service as compared with 2,000 who now order *Proceedings* a year, a much broader service will be rendered to the membership. The Publication Committee is grateful to all members who answered the questionnaire and for the many valuable suggestions received.

Each of the new publications will include only the formal papers which have been presented at meetings and which have been recommended for publication in *Transactions*. Each paper will be collated with the discussion, if any. *Electronics and Communication* will contain the formal papers sponsored by technical committees in the Communication Division and in the Science and Electronics Division. *Applications and Industry* will carry the formal papers sponsored by the technical committees in the General Applications and Industry Divisions. *Power Apparatus and Systems* will contain the formal papers sponsored by the technical committees in the Power Division and for the present a few *Transactions* papers sponsored by the general committees and the professional division committees such as research, safety, and education. Management papers will appear in any one of the three new publications most appropriate for the subject matter.

Beginning with the Summer General Meeting in June, the papers will not be printed individually due to the change in production methods; thus it will not be possible any longer to furnish authors with reprint orders in quantities of 100 or more at low incremental costs. Authors will be quoted regular reprint prices (cost plus 10 per cent) in quantities of 100 or more when proofs are furnished.

AIEE Annual Transactions

With the adoption of a divisional plan of publication, the bound volumes of *Transactions* beginning with Volume 71, 1952, instead of being issued semiannually, will be issued annually (early in 1953) in three parts as follows:

AIEE Transactions
Part 1. *Electronics and Communication*

AIEE Transactions
Part 2. *Applications and Industry*

AIEE Transactions
Part 3. *Power Apparatus and Systems*

Each part of the *Transactions*, bound in cloth with a stiff cover at the end of the year, will have the identical contents as the corresponding six issues of the bimonthly publication. Savings will be effected by overprinting the pages for *Transactions* at the same time the bimonthly publications are

Table I. Months of Issue and Subject Matter to Appear in Each of Three New Publications Tentatively Titled

Electronics and Communication July, Sept., Nov., Jan., March, May	Applications and Industry July, Sept., Nov., Jan., March, May	Power Apparatus and Systems Aug., Oct., Dec., Feb., April, June
Communication Switching Systems	Air Transportation	Carrier Current
Radio Communications Systems	Domestic and Commercial Applications	Insulated Conductors
Special Communications Applications	Land Transportation	Power Generation
Telegraph Systems	Marine Transportation	Protective Devices
Television and Aural Broadcasting Systems	Production and Application of Light	Relays
Wire Communications Systems	Chemical, Electrochemical and Electrothermal Applications	Rotating Machinery
Basic Sciences	Electric Heating	Substations
Computing Devices	Electric Welding	Switchgear
Electrical Techniques in Medicine and Biology	Feedback Control Systems	System Engineering
Electronic Power Converters	General Industry Applications	Transformers
Electronics	Industrial Control	Transmission and Distribution
Instruments and Measurements	Industrial Power Systems	
Magnetic Amplifiers	Mining and Metal Industry	Education
Metallic Rectifiers		Safety
Nucleonics		Research

printed and there will be less spoilage of paper. The procedure also will simplify indexing and the need for prefix numbers for each part on the pages. The usefulness will be enhanced as most members will need only one part which will take up less space on the shelves.

Member Subscriptions. To offset increases in printing prices and paper during the past few years as well as mailing and binding costs, the combination subscription to all three parts of *Transactions* beginning with Volume 71, 1952, is offered to members at a price of $6.00 per year. Members may subscribe to any one part at a price of $3.00 per year. A subscription card will be sent to all members, and the placing of subscriptions should be deferred until that time.

Nonmember Subscriptions. An advance combination subscription to all three parts of *Transactions* beginning with Volume 71, 1952, is offered to nonmembers at a price of $12.00 per year payable in advance (plus $1.00 extra for foreign postage payable in advance in New York exchange).

An advance combination subscription to any two parts of *Transactions* beginning with Volume 71, 1952, is offered to nonmembers at a price of $10.00 per year (plus $1.00 extra for foreign postage payable in advance in New York exchange).

An advance subscription to any one of the three parts of *Transactions* beginning with Volume 71, 1952, is offered to nonmembers at a price of $6.00 per year (plus 75 cents extra for foreign postage payable in advance in New York exchange).

A discount of 25 per cent will be allowed on all three nonmember subscriptions to college and public libraries. Publishers and subscription agencies may be allowed a discount of 15 per cent.

Electrical Engineering

No changes are contemplated in *Electrical Engineering* for the present. This is the official monthly publication of the Institute which is distributed automatically to all members and Student members in good standing. The contents will consist of general interest articles, technical articles of broad interest, a section on "Institute Activities," and another on "Current Interest."

Nonmember Subscriptions. An advance subscription to *Electrical Engineering* is offered to nonmembers at a price of $12.00 per year (plus $1.00 extra for foreign postage payable in advance in New York exchange).

Combination advance subscription to *Electrical Engineering* and *Transactions* (three parts) beginning with Volume 71, 1952, on a concurrent calendar year basis to a single addressee is $16.00 per year (plus $2.00 extra for foreign postage payable in advance in New York exchange).

A discount of 25 per cent will be allowed to college and public libraries. Publishers and subscription agencies may be allowed a discount of 15 per cent.

Preprints

Photolithographic copies of numbered papers will be available as heretofore in advance of meetings and most of them are available for a year or so after meetings. These are sold to members at a price of 30 cents each (to nonmembers 60 cents each). Please order by number and enclose remittance.

All subscriptions to any of the publications and remittances should be sent to AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

Future AIEE Meetings

South West District Meeting (*page 280*)
Jefferson Hotel, St. Louis, Mo.
April 15–17, 1952
(*Final date for submitting papers—closed*)

Joint AIEE-AWS-IEESD Welding Conference
Rackham Memorial Building, Detroit, Mich.
April 16–18, 1952

North Eastern District Meeting (*page 281*)
Arlington Hotel, Binghamton, N. Y.
April 30–May 2, 1952
(*Final date for submitting papers—closed*)

Joint AIEE-IRE-RTMA Conference on Progress in Quality of Electronic Components
Washington, D. C.
May 5–7, 1952

AIEE Conference on Electronic Converter Applications and Tubes (*page 281*)
William Penn Hotel, Pittsburgh, Pa.
May 19–20, 1952

Summer General Meeting (*page 282*)
Hotel Nicollet, Minneapolis, Minn.
June 23–27, 1952
(*Final date for submitting papers—March 25*)

Pacific General Meeting
Phoenix, Ariz.
August 19–22, 1952
(*Final date for submitting papers—May 21*)

AIEE Participation in Centennial of Engineering
Congress Hotel, Chicago, Ill.
September 10–12, 1952

Fall General Meeting
New Orleans, La.
October 13–17, 1952
(*Final date for submitting papers—June 13*)

Middle Eastern District Meeting
Commodore Perry Hotel, Toledo, Ohio
October 28–30, 1952
(*Final date for submitting papers—July 30*)

South West District Meeting to Offer Full Technical and Social Program

The AIEE South West District Meeting to be held at the Jefferson Hotel in St. Louis, Mo., April 15 through April 17, 1952, is designed to appeal to all electrical engineers regardless of their specialization. The broad and varied technical program will be augmented by a full social program and interesting inspection trips. The Institute's Board of Directors will hold its spring meeting in St. Louis on Thursday, April 17.

Student sessions will be held at Washington University in St. Louis April 18–19 to permit maximum contact between the students and the practicing engineers. All students are encouraged to attend the sessions of the District Meeting prior to their regular sessions, and they are welcome to attend any of the social functions.

This District has been selected by the Air Transportation Committee for its annual meeting. It is hoped that members from all parts of the country will attend. This selection is felt to be appropriate because of the central location of St. Louis, the McDonnell Aircraft Plant here, and the large number of component parts manufacturers in this area. All members and guests may attend these sessions.

GENERAL SESSION AND LUNCHEON

The General Session will be held at 10:00 a.m. April 15 under the chairmanship of H. R. Fritz of the Southwestern Bell Telephone Company. President F. O. McMillan will address the session on "Our Heritage From Engineering Education." J. B. Thomas, President and General Manager of the Texas Electric Service Company, will deliver a talk entitled "Research, Development, and Utilization of Electrical Energy."

The General Session will then be adjourned for luncheon at the Jefferson Hotel. The luncheon chairman is R. N. Slinger, the Chairman of the St. Louis section. The speaker at the luncheon will be L. W. McLeod, Vice-President of Westinghouse Electric Corporation, who will deliver an illustrated talk on "The Land of Rich Rewards"; this will focus attention on the major industries of the South West District, accenting the industrial growth in this area during the last decade.

ENTERTAINMENT

Tuesday, April 15

12:15 p.m.	Get-together luncheon in the Ivory Room, $2.50 per person. The men and the ladies are invited to attend this luncheon
5:30 p.m.	Pre-Smoker gathering in the Ivory Room. Delegates may purchase the refreshments they require and use this opportunity to renew friendships before the Smoker
6:30 p.m.	Stag Dinner and entertainment in the Gold Room, $6.00 per person

Wednesday, April 16

7:00 p.m.	Dinner, entertainment, and dancing in the Gold Room, $6.00 per person. Members of the AIEE Student Branches and their dates will be admitted free to the dancing

LADIES' PROGRAM

Tuesday, April 15

9:00 a.m. to 6:00 p.m.	The East Room on the mezzanine floor of Jefferson Hotel will be headquarters for the visiting ladies. A member of the Ladies' Committee will be on hand at all times to help the ladies arrange shopping tours, individual card games, and so forth
12:15 p.m.	Get-together luncheon in the Ivory Room, $2.50 per person. Tickets to be secured at time of registration
6:30 p.m.	Dinner, bridge, and canasta, $2.50 per person

Wednesday, April 16

12:15 p.m.	Luncheon and fashion show, $2.50 per person
7:00 p.m.	Dinner, entertainment, and dancing in the Gold Room, $6.00 per person.

Thursday, April 17

10:00 a.m.	Shopping tour or tour of the city. Arrangements for the shopping tour can be made with members of the Ladies' Committee. Those who wish to make a tour of the city should signify their intention at time of registration. It is planned that this tour will commence at a mid-point for luncheon

HOTEL ACCOMMODATIONS

The Hotel Jefferson has been designated as Headquarters by the District Meeting Committee. To be sure of hotel accommodations, reservations should be made prior to March 15 and sent directly to Reservation Department, Hotel Jefferson, St. Louis 1, Mo.

Other nearby hotels are: Hotel Statler, Hotel Lenox, and Hotel Mayfair.

Please send a copy of your reservation request to the Hotel Committee Chairman, Mr. H. M. Duphorne, c/o Southwestern Bell Telephone Company, 1010 Pine Street, St. Louis 1, Mo.

The rates at the Hotel Jefferson are:

Single Room with Bath	$ 5.50 to $ 8.50
Double Room Double Bed	7.50 to 11.50
Double Room Twin Beds	8.50 to 11.50
Parlor Suites	19.00 to 30.50

Hotel reservations for students will be handled by the Faculty Counselors for the student branches.

DISTRICT MEETING COMMITTEE

Members of the South West District Meeting Committee are: I. T. Monseth, *General Chairman;* R. C. Horn, *Vice-Chairman;* R. W. Schoetker, *Secretary-Treasurer;* H. R. Fritz, *District Vice-President;* R. G. Meyerand, *District Secretary;* R. N. Slinger, *Chairman, St. Louis Section;* C. B. Fall, *Finance;* H. M. Duphorne, *Hotel;* J. S. Malsbary, *Meetings and Papers;* E. S. Rehagen, *Entertainment;* O. L. Luft, *Registration;* S. C. Sachs, *Publicity;* E. G. McLagan, *Transportation and Trips;* R. J. W. Koopman, *Student Activity;* and Mrs. G. S. Whitlow, *Ladies' Activities.*

Science Abstracts of IEE Available to AIEE Members

Science Abstracts is a monthly publication, covering the fields of physics and electrical engineering, published by The Institution of Electrical Engineers (IEE) in London, England. It is designed to keep the working scientist and engineer in close touch with current progress in these fields by giving full abstracts of articles and papers published in technical and scientific journals.

Science Abstracts is published in two sections, A (Physics) and B (Electrical Engineering), containing 1,000 to 1,300 abstracts drawn from over 700 British, American, and foreign periodicals and annuals; the two annual volumes together thus contain 12,000 to 15,000 abstracts. Author and Alphabetical Subject indexes are provided.

AIEE members may subscribe to *Science Abstracts* at one-half the full subscription rate. For further details, see the advertisement on page 14A of this issue.

Dean Kimball and J. F. Fairman to Speak at North Eastern District Meeting

Celebration of the 50th anniversary of the Ithaca Section will coincide with the AIEE North Eastern District Meeting to be held April 30–May 2 in Binghamton, N. Y. Speaking in observance of the anniversary will be the former Dean of Engineering at Cornell University, Professor Emeritus Dexter S. Kimball. "Dean" Kimball is well known for holding audience interest with stories drawn from his rich background of experience in many fields. James F. Fairman, Defense Electric Power Administrator, and a past president of AIEE, will be the principal speaker at the Thursday evening banquet. This affair will be preceded by a smoker on Wednesday evening.

The Ladies' Program includes a get-acquainted tea on Wednesday followed by either a stage play or dinner. Inspection trips have been planned for Thursday morning, followed by a luncheon. There will be a sightseeing tour on Thursday afternoon. On Friday morning a meeting for coffee will precede another trip to a point of general interest. Friday afternoon will be left open for shopping trips. Transportation will be available for all of the planned portions of the Ladies' Program.

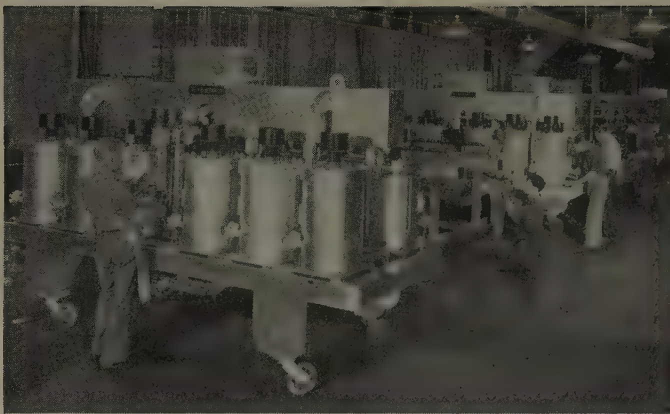
Members of the North Eastern District Meeting Committee are: W. W. Perry, *General Chairman;* N. L. Platt, *Publicity;* J. P. Peterson, *Inspection Trips and Transportation* and *Chairman, Binghamton Subsection;* J. R. Stover, *Banquet and Smoker;* A. O. Kenyon, *Hotels and Registration;* L. F. McGowan, *Budget and Finance;* J. E. Gahagan, *Ladies' Program;* J. G. Tarboux, *Vice-President AIEE, District 1;* M. S. McIlroy and H. L. Livingood, *Technical Papers;* W. H. Erickson, *District Chairman, Student Activities;* E. B. Alexander, *District Secretary;* and S. W. Zimmerman, *Chairman, Ithaca Section.*

Committee members for the North Eastern District Meeting are, front row, left to right, N. L. Platt, W. W. Perry, and J. P. Peterson. Back row, left to right, J. R. Stover, A. O. Kenyon, J. E. Gahagan, and L. F. McGowan

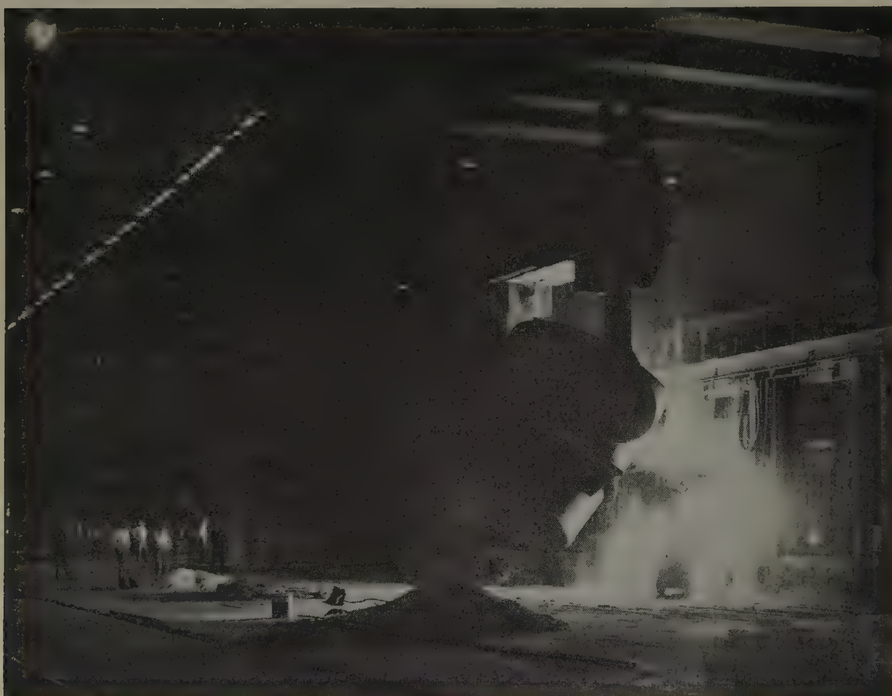
Electronic Converter Applications and Tubes Conference to Be Held May 19–20

Four technical sessions on the application of large pool tubes and equivalent devices to rectifiers are scheduled for the AIEE Conference on Electronic Converter Applications and Tubes, to be held May 19–20 at the William Penn Hotel in Pittsburgh, Pa. Two inspection trips are planned for the afternoon of May 19. One trip will be to the Edgar Thomson Works and the Homestead Works of the United States Steel Company. The second trip will be to the East Pittsburgh Works of the Westinghouse Electric Corporation to see ignitron rectifier manufacturing and testing.

The inspection trip to the Edgar Thomson Works and the Homestead Works will



Ignitron rectifier manufacture at the East Pittsburgh Works of Westinghouse, which will be seen on an inspection trip at the Conference on Electronic Converter Applications and Tubes to be held May 19–20 in Pittsburgh, Pa.



Molten pig iron is being added to the charge in the open hearth furnaces at the Homestead Works, one of the inspection trips scheduled during the Electronic Converter Conference. The ladle cranes and other equipment are supplied with 250-volt d-c power obtained from two 1,500-kw rectifiers

include visits to the electronic frequency changer, the number 5 open hearth plant, the 45-inch slabbing mill, and the 160-inch plate mill.

Edgar Thomson Works generates power at both 25 cycles and 60 cycles, supplemented with purchased power at 60 cycles. The frequency changer consists of two units having a combined rating of 20,000 kw. The a-c power from one system is rectified to d-c power at approximately 15,000 volts, then inverted to a-c power in the other system. The over-all efficiency is approximately 95 per cent. Amount and direction of power flow are remotely controlled, and depend upon the power requirements of each system.

Number 5 open hearth has eleven 225-ton basic stationary open hearth furnaces and two 800-ton hot metal mixers served by four 12-ton floor type charging machines and nine ladle cranes. The 45-inch universal slabbing mill consists of a single 45-inch stand—each horizontal roll being driven independently by a 5,000-horsepower 700-volt d-c reversing motor while the two 36-inch diameter vertical rolls are driven through overhead gear sets by a single 3,000-horsepower 700-volt d-c reversing motor. The 160-inch plate mill consists of two stands; the first is a 2-high 36-inch by 76-inch scale breaker continuously driven by a 1,600-horsepower wound-rotor induction motor; the second or main stand is a 4-high 160-inch wide reversing plate mill.

The second inspection trip will be to the East Pittsburgh Works of the Westinghouse Electric Corporation to visit the pumped and sealed ignitron rectifier manufacturing facilities and the low-voltage and high-voltage rectifier testing equipment. The machining, assembling, and degassing sections will be visited. The manufacture of excitation cubicles and assembly of heat exchanger for rectifiers will be seen. A rectifier switchgear manufacturing section also will be visited.

Additional inspection trips will be organized for smaller groups if there is sufficient interest. It will be necessary to comply with such security regulations as are in force at the time of the trips.

Plans Progressing for AIEE 1952 Summer General Meeting

The 1952 Summer General Meeting, to be held the week of June 23 at the Nicollet Hotel in Minneapolis, Minn., will mark the Fiftieth Anniversary of the Minnesota Section. Arrangements to commemorate this event at the meeting are being made by a committee headed by H. W. Meyer.

A feature of this meeting will be the Annual Meeting of the American Institute of Electrical Engineers and introduction of its new President.

W. H. Gille is in charge of General Sessions and P. A. Cartwright of the Technical Program. A special program of activities for ladies is being developed by a committee headed by Mrs. H. E. Hartig. Student Activities are in charge of J. H. Kuhlmann. A reception, a dinner dance, and several noon-time luncheons will be held during the week of the meeting. E. H. Hagensick is Chairman of the Entertainment Committee planning these events.

Inspection trips are being arranged by P. G. Bowman, and sports events by R. G. Lynn. The latter events will include golf and tennis tournaments, a fishing contest, and a sailboat race on one of the lakes in Minneapolis. Prizes for these events will be awarded at one of the luncheons. In addition to the inspection trips to local points of interest, a plane trip to the open-pit mining activities on the Minnesota Iron Range is being arranged under the auspices of the Arrowhead Section.

Other members of the General Committee for the 1952 Summer General Meeting are: R. R. Herrmann, *General Chairman;* H. E. Hartig, *Vice-Chairman;* H. P. Bruncke, *Secretary;* A. J. Hendry, *Treasurer;* J. R. North, *Vice-President District 5;* D. D. Ewing, *Director;* R. B. Wiprud, *Chairman Arrowhead Section;* G. B. Germain, *Chairman Minnesota Section;* and R. N. Faiman, *Chairman Red River Valley Division.*

The Chairmen of the Operating Committees are: R. H. Olson, *Finance and Budget;* L. A. Rietow, *Hotel Reservations;* E. A. Wold, *Printing;* R. M. Kalb, *Publicity;* E. B. Doescher, *Registration;* and H. E. McWethy, *Transportation.*

Official Nominees Announced for 1952 AIEE National Election

Donald A. Quarles, Vice-President of Bell Telephone Laboratories, Inc., was nominated for the AIEE presidency by the Nominating Committee at its meeting held in New York, N. Y., January 23, 1952. Others named for election to Institute offices for terms beginning August 1, 1952, are:

For Vice-Presidents:

W. Scott Hill, Manager Commercial Engineering Division, Transformer and Allied Products Division, General Electric Company, Pittsfield, Mass. (District 1)

M. D. Hooven, Electrical Engineer, Electric

Engineering Department, Public Service Electric and Gas Company, Newark, N. J. (District 3)

W. L. Cassell, Professor of Electrical Engineering, Iowa State College, Ames, Iowa (District 5)

C. Myron Lytle, Engineering Manager, Kansas City Power and Light Company, Kansas City, Mo. (District 7)

Thomas Ingledow, Vice-President and Chief Engineer, British Columbia Electric Company, Ltd., Vancouver, B. C., Canada (District 9)

For Directors:

A. C. Muir, Electrical Engineer, Berwind-White Coal Mining Company, Philadelphia, Pa.

N. C. Pearcy, Chief Electrical Engineer, Pioneer Service and Engineering Company, Chicago, Ill.

C. S. Purnell, Eastern Agency and Construction Manager, Agency and Construction Department, Westinghouse Electric Corporation, New York, N. Y.

For Treasurer:

Professor W. I. Slichter, Professor Emeritus of Electrical Engineering, Columbia University, New York, N. Y., was nominated for Treasurer, but Professor Slichter found it necessary to decline the nomination, whereupon the executive committee of the Nominating Committee nominated N. S. Hibshman, Dean, School of Engineering, Pratt Institute, Brooklyn, N. Y.

The Nominating Committee, in accordance with the Constitution and Bylaws, consists of 15 members, one selected by the executive committee of each of the ten geographical Districts, and five selected by the Board of Directors from its own membership.

The Constitution and Bylaws of the Institute require publication in *Electrical Engineering* of the nominations made by the Nominating Committee. Provision is made for independent nominations as indicated in the following excerpts from the Constitution and Bylaws:

Constitution: Section 32. Independent nominations may be made by a petition of twenty-five (25) or more corporate members sent to the Secretary when and as provided in the Bylaws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

Bylaws: Section 24. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 32 (Constitution), must be received by the secretary of the Nominating Committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the Nominating Committee in accordance with Article VI of the Constitution and sent by the Secretary to all qualified voters on or before April 15 of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

A list of members of the Nominating Committee appeared in the February issue of *Electrical Engineering*, page 192.

To enable those Institute members not acquainted personally with the nominees to learn something about their engineering careers and their qualifications for the Institute offices to which they have been nominated, brief biographical sketches are scheduled for inclusion in the "AIEE Personalities" columns of the April issue.

AIEE Endorses Push-Pull Method of Artificial Respiration

The following resolution was adopted by the AIEE Committee on Safety at a meeting on January 23, 1952:

RESOLVED: That the Committee on Safety AIEE endorses the Back-Pressure Arm-Lift Method and the other Push-Pull Method of artificial respiration as recently adopted by the American Red Cross, the Armed Services, and others as the preferred general-use methods of artificial respiration. That the Pole-Top Method continues to be recognized as the preferred method of artificial respiration in cases involving persons receiving electric shocks while working on poles. That this resolution be submitted to the Board of Directors, AIEE, with recommendation for favorable consideration, and that this matter be called to the attention of members of the Institute through publication in *Electrical Engineering* magazine.

The AIEE Board of Directors, at its meeting held on January 24, 1952, voted to approve the resolution of the Committee on Safety.

69 Technical Sessions Attract Record Attendance at Winter General Meeting

The 1952 AIEE Winter General Meeting, held in New York, N. Y., from January 21 through 25, with headquarters at the Hotel Statler, was the largest program in the history of the Institute, both as to the number of technical sessions held and the attendance. In 69 sessions 280 papers were given: 102 Transactions, 164 Conference, and 14 Advance-Copies-Only. There was a lecture demonstration on fluid mapper patterns Wednesday evening. Over 3,800 members and guests attended the meeting.

On the business side, more than 100 committee and luncheon meetings were held as well as the meeting of the Sections Committee on Tuesday, a Forum of Technical Committee Chairmen on Wednesday, and an all-day meeting of the Board of Directors on Thursday.

On the social side, a smoker was held in the ballroom of the Hotel Commodore on Tuesday evening and a dinner-dance in the ballroom of the Hotel Statler on Thursday evening. In addition to the dinner-dance, a special program for the entertainment of the visiting ladies, consisting of a tea and get-together, a dinner party and entertainment, a visit to the Hayden Planetarium, and a luncheon and fashion show at Sherry's, was arranged.

Many took advantage of a series of 13 inspection trips arranged to nearby industries, utilities, and the United States Signal Corps Photographic Center, as well as the New York Curb Exchange, Steinway and Sons, Radio City Music Hall, New York Harbor Radar Installation, and the new Bus Terminal.

GENERAL SESSION

President McMillan's Address. AIEE President McMillan opened the General Session by speaking of some obligations that engineers have neglected. He emphasized the necessity for reaffirming the "Statement of Principles of Professional Conduct," and told of the critical shortage of engineers

Dr. Charles F. Wagner (at extreme left) is receiving the Edison Medal and scroll from President McMillan, and T. M. Linville (at extreme right) is presenting the Alfred Noble Prize to Eldo C. Koenig

Charles E. Wilson, Director of Defense Mobilization, addresses the General Session of the AIEE Winter General Meeting on "The Challenge of the Future." Mr. Wilson looks upon defense mobilization not as a grinding duty, but as an opportunity to defend the principles upon which our way of life is founded. President McMillan is seen at the right

Charles E. Wilson's Address. In introducing Mr. Wilson, President McMillan said that the guest speaker had been in the electrical industry for 51 years, and that he was president of the General Electric Company during the period of its greatest expansion. About 14 months ago Mr. Wilson went to Washington at the invitation of President Truman to take a job which was vitally important to the nation's security. Three years ago he talked to the Institute members at the Winter Meeting about the professional estate, using Emerson's "American Scholar" essay as his text. At that time Mr. Wilson said that understanding and action were most important to the professional man, that he should not neglect citizenship for his business, and that he has a particular obligation to society to understand and act.

Charles E. Wilson, Director of Defense Mobilization, then addressed the members on building for defense. His address, entitled "The Challenge of the Future," emphasized the need for future planning so that the situation would be "like the shotgun behind the farmer's door which never had to be fired because all would-be burglars knew it was ready for use at any time." Mr. Wilson's speech is printed in its entirety on pages 203–06.

which the public does not seem to realize. He referred to the desire of AIEE and other societies to evolve an engineering unity organization. The full text of the address appears on pages 201–03 of this issue.

Edison Medal. The 1951 Edison Medal was presented to Charles F. Wagner, Consulting Engineer, Westinghouse Electric Corporation, at the General Session. Professor J. F. Calvert gave the origin of the medal; A. C. Monteith gave a biographical sketch of the Medalist; and Dr. Wagner responded with a talk on "Thirty Years of Power Transmission." Full texts of these three addresses are to be found on pages 216–19 of this issue.

Alfred Noble Prize. The Alfred Noble Prize was presented to Eldo C. Koenig, Allis-Chalmers Manufacturing Company, by T. M. Linville, representing the American Society of Civil Engineers; the prize-winning paper was entitled "An Electric Analogue Computer Using the Photocell as a Nonlinear Element."

Institute Paper Prizes. James J. Orr, Chairman of the Committee on Award of Institute Prizes, announced the winners of these prizes. The Best Student Prize Paper was awarded to Russell E. Peterson of the University of Utah. Second prize went to Samuel Corbin and Harold R. Moore of Mississippi State College.

The Institute prizes, awarded on a division basis, were as follows: Communication Division, first prize to J. J. Gilbert, second prize to C. H. Cramer; Industry Division, first prize to A. M. Hopkin, second prize to H. Harris, Jr., M. J. Kirby, and E. F. von Arx; Power Division, first prize to I. W. Gross, Otto Naef, C. F. Wagner, and R. L. Tremaine, second prize to W. K. Sonnemann; Science and Electronics Division, first prize to R. A. Ramey, second prize to G. W. Penney. There was no award for the General Applications Division.

A more complete account of these awards will be found in the February issue of *Electrical Engineering* on page 190.

1952 Centennial. C. S. Proctor, President of the American Society of Civil Engineers, announced the 1952 Centennial of Engineering, to be held in Chicago, Ill., in September of this year. The exhibit will depict 100 years of engineering progress. Forty-seven national and international organizations so far have said that they will collaborate. The Museum of Science and Industry exhibits will stay for 5 years, and it is expected that 8,000,000 people will see them. Present indications are that 25,000 engineers and their families will attend the Centennial.

WINTER GENERAL MEETING COMMITTEE

The members of the 1952 Winter General Meeting Committee who helped make the meeting such a success were: G. J. Lowell, *Chairman;* C. T. Hatcher, *Vice-Chairman;* J. J. Anderson, *Secretary;* W. J. Barrett, *Budget Co-ordinator;* C. S. Purnell, *Vice-President, District 3, AIEE;* M. M. Brandon, *Technical Program;* J. P. Neubauer, D. W. Taylor, J. D. Tebo, D. T. Braymer, *General Session;* R. T. Weil, *Monitors;* G. T. Minasian, J. B. Harris, Jr., *Publicity;* C. N. Metcalf, *Hotel Accommodations;* E. R. Thomas, *Registration;* D. M. Quick, *Smoker;* Mrs. R. F. Brower, *Ladies' Entertainment;* J. G. Derse, *Dinner-Dance;* F. P. Josslon, *Inspection Trips;* J. G. Aldworth, *Theater-Radio.*

Prize Awards and Publications Discussed at Forum of Technical Committee Chairmen

The fourth Forum of Technical Committee Chairmen was held Wednesday evening, January 23, with M. M. Brandon, Chairman, Technical Program Committee, presiding.

AWARD OF INSTITUTE PRIZES

In introducing the subject, J. J. Orr, Chairman of the Committee on Award of Institute Prizes, made it clear that he was proposing changes only in the Institute prize awards and not District, Section, or Branch prizes. He brought out that cash prizes for all but the best student paper should be abolished, as the practice was neither dignified nor productive of particularly good papers. Further, he suggested that cash prizes in each division be abolished; that prizes of certificates only be awarded to authors who had papers accepted for the first time; that in cases of multiauthorship, all the authors must be "first timers." He proposed that divisions should nominate the most worthy papers to the Committee on Prize Awards which will make the final decision, and that the designations "best paper," "second-best paper," and so on, be abolished.

W. R. Brownlee, Chairman of the Power Division Committee, said that his committee was in general agreement with the proposals of Mr. Orr except on limiting the awards to certificates only and that the present award plans should be maintained until a better method could be evolved. Mr. Brownlee said he was not expressing the opinion of the Division.

Victor Siegfried, Industry Division Committee, explained that the present prize plan came from the Sections Committee. Moreover, prize plans are always changing and something definite should be established as prizes are needed.

B. G. A. Skrotzki, Vice-Chairman of the Power Division Committee, told of the difficulty his committee had in differentiating between first, second, and third best papers.

The question of whether certificates or cash prizes be awarded was put to the Forum; the result was 22 for certificates only and 3 for cash awards.

Eta Kappa Nu Association Annual Dinner Held

The annual dinner given by Eta Kappa Nu to honor the Outstanding Young Electrical Engineer of 1951 was held on January 21, 1952, in the Tudor Room of the Henry Hudson Hotel in New York City. Louis G. Gitzendanner of the General Electric Company, Schenectady, N. Y., was the winner of the 1951 Eta Kappa Nu Recognition Award for his skillful management of concurrent development of varied complex electromechanical devices, his inspirational leadership of associates, and his unselfish participation in school and professional affairs.

Toastmaster of the dinner was National President Dean Ovid W. Eshbach of Northwestern Technological Institute. Dean Eshbach presented Eric A. Walker of Pennsylvania State College, who introduced the two winners of the Honorable Mention Awards: Burton R. Lester of the Electronics Division, General Electric Company, Syracuse, N. Y., who received the award by virtue of his outstanding ability in the development of military electronic systems and his inspired leadership of professional groups and young people; and Robert L. Trent, Bell Telephone Laboratories, Inc., Murray Hill, N. J., who was given the award for his contributions to advanced development and design of communications and supersonic systems, and for his enthusiastic participation in community, church, and local government affairs.

H. A. Winne, Vice-President of General Electric Company, then introduced the 1951 winner, Mr. Gitzendanner, who had received an Honorable Mention Award in 1949. He spoke on "Opportunity."

Three men were elected to Eminent Membership in Eta Kappa Nu in recognition of their leadership and contributions to the field of electrical engineering. These men, Karl B. McEachron of General Electric Company, S. H. Mortenson of Allis-Chalmers Manufacturing Company, and Professor William H. Timbie, formerly of Massachusetts Institute of Technology, were presented by Dean Eshbach. Each acknowledged with a few words of appreciation.

The program closed with the General Electric Company "House of Magic" show. This was an entertaining demonstration, in a nontechnical way, of such subjects as plastic foam, photoelectricity, high-frequency induction, and stroboscopic light.

The Jury of Award consisted of Philip Sporn, O. W. Eshbach, S. H. Mortenson, Eric A. Walker, F. E. Sanford, and J. O. Perrine. The Chairman of the Award Organization Committee was Elies Elvove.

The question of whether division prizes should be superceded by a system of over-all Institute prizes was then put to the Forum; the majority expressed the opinion that division prizes should be retained.

A further vote was taken as to whether the Forum was in favor of retaining first and second division prizes or just having certificates of awards; the majority were in favor of just issuing certificates.

YEARLY ENGINEERING DEVELOPMENTS

K. B. McEachron, Chairman, Publication Committee, reviewed the "Engineering Developments" of the year which is published each January in *Electrical Engineering* and then said that progress made during the previous year only should be featured. He then asked C. S. Rich, editor of *Electrical Engineering*, to explain some of the problems he had encountered.

Mr. Rich told of the procedure of sending letters to the chairmen of all technical committees in September asking for a 300-word review of outstanding developments in their respective fields to be received by November 15. By this date last year, eight reports had been received and fifteen more by December 3—a response from about only one-half of the committees. Most of the reports received were over 1,000 words in length, whereas only 300 or less were desired.

The question was then asked the Forum if they considered the annual review worth while; the vote was 19 to 7 for the review.

After several members had given their ideas of the value of the contents and arrangement of the review, Mr. Siegfried stated that it was something everyone can read with profit and Dr. Steinberg agreed with Mr. Brandon that most readers of *Electrical Engineering* are not specialists and so would appreciate learning what work the other fellow is doing.

Dr. McEachron discussed the difficulty of getting retiring committee chairmen and those just assuming those posts to write the reviews. He suggested that throughout the year chairmen keep a list of new things in their particular fields, which they can hand on to their successors to assist them in writing a better and more concise review and to collect photographs to illustrate them.

DIVISIONAL PUBLICATIONS

Dr. McEachron then turned to the subject of the proposed divisional publications, the make-up and frequency of publication which he reviewed. He urged that the chairmen of committees other than those in the Power Division get more technical papers processed so that the two bimonthly publications—*Electronics and Communication* and *Applications and Industry*—will have enough material to make them worth while. An estimate was made that 129 technical papers would be presented at this Winter General Meeting, but only 101 were accepted, this decrease occurring in all divisions except the Power Division where there was an increase over the number of estimated papers. The speaker then outlined the plan for printing extra pages of the bimonthly publications for the three volumes of the *Transactions*.

Mr. Alger inquired if a paper would appear in more than one publication if it had an overlapping subject. Dr. McEachron said it would be published in only one place.

Mr. Harder, Chairman of Committee on Magnetic Amplifiers, inquired if the number of technical papers rejected was unusually high. Mr. Day, Secretary of the Technical Program Committee, replied that there were ten rejections of Winter General Meeting papers.

Mr. Rhea, Chairman of the Industry Division Committee, said that rejections of technical papers had been discussed in his committee. They asked that papers be given an accepted status "without prejudice" and be considered for *Transactions* later.

Mr. Heuman, Committee on Industrial Control, stated that they had valuable papers of current interest now but which would be of little interest in five years. He suggested such papers be presented at meetings as a numbered paper and then after a period of perhaps four months would be recommended for the *Transactions*. Discussions of such papers would have the same status as those of technical papers.

No action was taken on this, but Dr. McEachron gave the results on conference papers that the Publication Committee had gathered at the Fall General Meeting in Cleveland, showing that most authors of conference papers expressed a willingness to provide copies of their papers for distribution at the meetings.

Sections Committee Discusses Divisional Operation, Student Guidance, at January 22 Meeting

The Sections Committee, with C. S. Purnell, Chairman, presiding, met at the Hotel Statler on January 22. Reports were presented by chairmen of Institute Committees and Subcommittees on the progress made in various activities since the Summer General Meeting.

CHANGES IN SECTION ORGANIZATION

The first order of business concerned changes in Section organization status and territories. Unanimous approval was given for the following changes for recommendation to the Board of Directors.

1. Formation of the Monroe Subsection under sponsorship of the Shreveport Section, involving the transfer of certain Louisiana parishes from District 4 to District 7.
2. Formation of the Delaware Bay Section comprising the former Wilmington Division of the Philadelphia Section, embracing the counties of Newcastle in Delaware and Salem in New Jersey.
3. Formation of the Tampa Section, comprising the former Tampa Subsection of the Florida Section.
4. Change in name from Florida Section to Jacksonville Section.
5. Formation of the Adirondack Subsection of the Schenectady (N. Y.) Section.

(*Editor's Note:* The Board of Directors subsequently approved these recommendations at their meeting on January 24.)

DIVISIONAL OPERATION

The Divisional Operation of the Institute's Technical Committees was explained by M. D. Hooven, Director, who first reviewed the explanation of such activities. In the 1920's, there were ten Technical Committees, which number was doubled within the next 20 years. The Asheville Resolution

Photographed at the Winter General Meeting are, left to right, seated, Dr. Charles F. Wagner, Edison Medalist for 1951; AIEE President McMillan; and Eldo C. Koenig, winner of the Alfred Noble Prize; left to right, standing, are C. S. Purnell, Vice-President of AIEE District 3; A. C. Monteith, who told of the achievements of Dr. Wagner; H. H. Henline, AIEE Secretary; G. J. Lowell, Chairman, Winter General Meeting Committee; T. M. Linville, who introduced Mr. Koenig; and J. F. Calvert, who gave the Edison Medal history

in 1946 gave the final impetus to the movement of the activities into the divisional classifications and the technical committees fell into their natural places.

It is the main purpose of the AIEE to cover the field of electrical engineering as completely as possible and to achieve this end it is being proposed that the Technical Advisory Committee and the Technical Program Committee be combined into one committee known as the Committee on Technical Operations.

(*Editor's Note:* This recommendation was approved by the Board of Directors on January 24.)

FINANCES

The Chairman of the Finance Committee, W. J. Barrett, reported that although the Board of Directors now had the authority to change members' dues, it had not been found necessary to do so because for the past two years the Institute had been operating "in the black." He pointed out that the budget for this year would run approximately $960,000, and with strict economy being practiced Mr. Barrett was hopeful that it would be a profitable year. He looked for additional income, primarily from advertising in *Electrical Engineering* due to a recent increase in rates, plus increased revenue due to the growth of membership in the Institute. He pointed out that it was undesirable to curtail any of the Institute's services and assured the members that the Board of Directors would continue to work diligently toward this end.

Past President T. G. LeClair reported by a letter read by Mr. Purnell of the continued work by the Exploratory Group on a Unity Organization for the profession. He felt that much progress had been made toward the determination of a single, over-all plan which might be referred again to the Section membership for their comments and consideration, and said that he would report on this progress from time to time.

President F. O. McMillan spoke briefly and expressed his appreciation not only for the co-operation that he continued to receive from all members of the Institute but also for the fine work being done by all the Sections. He suggested that the Sections consider the formation of Ladies' Auxiliaries as another means of advancing Institute activities.

STUDENT GUIDANCE

In reporting to the meeting on Student Guidance, B. G. A. Skrotzki, Chairman, Engineers' Council for Professional Development (ECPD), National Committee on Student Guidance, told about their operations and the purpose of his committee. Much progress has been made in the last 14 years through the fine co-operation of the five Engineering Societies. He described specifically what is being done in the New York area and pointed out the advantages of planned meetings with high-school students and their counselors. In these meetings, the students are given every opportunity to ask questions and discuss all phases of an engineering profession. Mr. Skrotzki said that high-school students in this area had found this program very helpful and he stressed the fact that ECPD wanted to spread this type of work throughout the country.

In the open discussion which followed, it was brought out by Mr. Elgin Robertson that a Student Guidance plan had been operating in the Dallas, Tex., area for some time and that the results were extremely gratifying.

President McMillan said many students come entirely unprepared to undertake a college engineering course, therefore he felt it important that contacts with high-school pupils be made in the early stages of their high-school curriculum. He also emphasized the importance of working more closely with the high-school counselors toward this end.

COMMITTEE REPORTS

The Chairman of the Subcommittee of the Sections Committee, C. Clos, reported on the Section Growth Award Plan. This committee, consisting of Mr. Clos, Chairman, and F. S. Black, V. L. Ingersoll, and J. C. Strasbourger, is working on a plan by which two sets of awards for Section growth can be made next June at Minneapolis: one for the growth during Past President LeClair's administration, and the second for the growth during President McMillan's administration. In this way, the retiring President then would be able to award the prizes hereafter which had been won during his administration.

J. C. Woods, Chairman of the Membership Committee, reported that 39 per cent fewer students had applied for Associate membership during the period May 1, 1951, to December 31, 1951, as compared to the same period during 1950. On the other hand, there had been a 24-per-cent increase on applications from all sources other than students. He brought out that the technical programs offered by the Sections were what the Membership Committee had to sell and that these programs should be made as attractive as possible.

H. A. Dambly, Chairman of a Subcommittee of the Sections Committee, reported on the work that his committee had done in revising the "Technical Groups" booklet. Copies of this revised bulletin were distributed to those at the meeting, and the changes were explained. The revised booklet on the organization and operation of Technical Groups, which will be made available to the Sections, was accepted by the Sections Committee meeting.

G. T. Minasian, Chairman of the Public Relations Committee, spoke briefly on the problem of publicity at the Section level. He reported that the publicity kit had been brought up to date, and soon will be mailed out to all Sections. He urged that the Sections appoint Publicity Chairmen and offered the assistance of Raymond C. Mayer Associates, the Institute's public relations firm, to any Section which wanted to expand their activities.

F. W. Tatum, Chairman of the Committee on Student Branches, reported on the continuing problem of getting more students to become AIEE members, and how important it was to keep in touch with them after they had graduated from college. To encourage Student Branches, he suggested that the Sections hold regular joint meetings with them, that all of the students should be notified of these meetings, and that they should be welcomed and made to feel at

home. Another suggestion made by Mr. Tatum was for the Sections to consider having both the Student Counselor, as well as the Student Chairmen, serve on the Section Executive Committee.

Mr. Clos reported for C. B. Carpenter, Chairman, on the matter of Transfer activities. He asked that every Section have a local committee on Transfers and that it should be composed of Fellows and Members. The committee membership should be continuing—a 3-year membership is suggested—so that they would be familiar with the correct procedure of writing applications for membership transfers. A booklet recommending the procedure in Transfers work is under preparation. It is expected that it will be available later this year.

Following an informal discussion of Section activities, such as the establishment of Subsections, Prize Paper Contests, and methods of increasing meeting attendance, Mr. Purnell asked the Section representatives to come to the Summer General Meeting in Minneapolis prepared to discuss all phases of Section operation. He also pointed out that the theme for a forum discussion at that time would concern the critical shortage of engineering graduates, the need for increased student guidance in the high schools, and the necessity for increased public relations activities with students, teachers, parents, and the general public on engineering as a profession.

280 Technical and Conference Papers Presented at Winter Meeting in New York City

Electric Space Heating and Heat Pumps Session. New developments in the residential use of heat pumps was the main theme of the papers presented at the Monday morning session over which H. F. Hoebel, American Gas and Electric Service Corporation, presided.

The opening paper, presented by M. S. Oldacre, Utilities Research Commission, was "Experiences with the Compression-Type Water Heaters." This type of heat pump can supply hot water at low operating cost; it can provide air conditioning for one room in hot weather and act as a dehumidifier for basements. To the utility there is the advantage of low demand with a consequent lower cost of the distribution system. This paper covered the results of tests of both experimental and commercial models under laboratory and residential conditions.

A group of three conference papers covered residential heat-pump experiments in Philadelphia, Pa., conducted by the Philadelphia Electric Company, the papers being presented by that company's engineers. J. H. Harlow and G. E. Klapper presented the installation and operating data; A. H. Kidder and J. H. Neher discussed the earth as a heat source; and Constantine Bary suggested possibilities for practical applications. Tests were conducted on two homes in the suburbs with pipes buried in the yards through which a glycol solution was circulated. By this means heat could be either extracted from the earth for use in the houses or the process reversed in warm weather.

The final paper of the session, "A New Packaged Heat Pump," was given by H. G. Fifield, General Electric Company. After discussing the various types of heat "sources," the author described the air-to-air heat pump, which has been given extensive operating tests in different portions of the country.

Industrial Control Session. On the opening day of the meeting, a session on industrial controls was held. J. A. Cortelli, Clark Controller Company, presided over the session and four conference papers were presented.

In an effort to correlate the knowledge of control systems accumulated over 20 years of feedback control experience, O. W. Livingston, General Electric Company, presented a paper called "Fundamental Considerations in the Use of Feedback Control." The essential features of feedback control were explained in terms of a simple system, and some of the difficulties, such as time delay which may cause instability and the complex gain function, were mentioned. The development of a feedback system consists of synthesis and analysis. Differential equations are useful for analysis, but synthesis is achieved largely through practical experience. Various types of graphical methods for simplifying the problem were described by Mr. Livingston.

"Regulators from the Electronic Point of View" was the title of a paper given by E. H. Vedder, Westinghouse Electric Corporation. It was explained that electronic regulators are most useful where precise regulation is required, but the higher gain of these devices presents a problem of instability. Mr. Vedder defined the proper field of application of electronic regulators and compared them with rotating regulators and magnetic amplifiers for a number of uses. Generally the electronic devices are favored where precision, quick response, and flexibility are required, but fall behind in ease of maintenance, simplicity, and reliability. Some typical applications of electronic regulators in steel mills, paper mills, and synthetic fiber mills were discussed.

W. R. Harris, Westinghouse Electric Corporation, described the use of rotating regulators in his paper entitled "Rotating Regulator Applications in the Steel Industry." These regulators are used for the regulation of voltage, current, speed, torque, and tension. They are accurate and reliable over wide ranges and can be built for practically any required output. These advantages, plus the fact that they easily provide reverse power, make them particularly suitable for the steel industry. Mr. Harris also gave a comparison between rotating regulators, electronic devices, and magnetic amplifiers. This evaluation in general agreed rather well with that given in the preceding paper, although Mr. Harris in some cases favored the rotating controller where Mr. Vedder favored electronic regulators.

The final paper of this session was "Synthesizing the Armature Circuit of a D. C. Shunt Motor Supplied by Half Wave Rectifiers" by W. S. Kupfer, Jr., and E. E. Moyer, both of Rensselaer Polytechnic Institute. This described a novel method of achieving an equivalent circuit for d-c shunt motors by using a series inductance, resistance, capacitance circuit. Values for the circuit elements are selected by observing waveshapes on the circuit rather than actual voltages, and it is possible to synthesize a circuit with waveshapes that look exactly

One of the inspection trips during the AIEE Winter General Meeting was to The Okonite Company cable plant in Passaic, N. J. Samples from the Okonite cable museum interest C. H. Funderburg, Union Carbide and Carbon Company; T. C. White, Chicago District Electric Generating Company; M. F. Elliott, Public Service Company of Northern Illinois; and F. F. Leib, Copperweld Steel Company

like those of a d-c motor. By using the terminal voltage of the circuit as equivalent to speed, a speed-load characteristic can be obtained which is remarkably similar to that of the d-c motor for which the circuit is equivalent. Other characteristics of the circuit also closely resemble those of the motor.

Electronics in Industry. Three conference papers and two technical papers were presented on Tuesday morning in a session devoted to application of electronics in industry. L. A. Umansky, General Electric Company, presided.

The textile industry received first attention in a paper titled "Electronics in Textiles" by F. D. Snyder, Westinghouse Electric Corporation, and J. T. Jester, General Electric Company. In this field electronics at present has its greatest application in controlling drive motor speeds. Standard control equipment is used, and some of the machines on which it is used are constant tension equipment, loop fixing devices, and full-fashion hosiery machines. Good tension control is especially important for knitting and weaving. A magnetic shuttle detector was described which quickly stops the weaving machine if the shuttle drops out of place. A small piece of iron attached to the shuttle causes pulses to be generated in two magnetic circuits on either end of the shuttle's path. If the shuttle does not appear at the end of its path at the right time, braking equipment goes into action immediately.

Other devices described for the textile industry were a seam detector to release the pressure between two calender rolls as a seam passes to avoid damage to the rolls; electrostatic air cleaners; testing equipment for laboratory work; and radioactive tracers for wool and cotton research. In general, textile men are only beginning to realize the advantages of electronic control. They are somewhat reluctant to try these devices, mostly because they do not have trained maintenance personnel and because they have little faith in the vacuum tubes.

"Electronic Control of Machine Tools" was the title of the second paper presented by J. M. Delfs, General Electric Company. It was pointed out that the increased cost of applying electronic controls to machines must be justified by improved performance because of the highly competitive nature of the machine tool field. A number of applications of electronics in this field have been developed, and by far the largest percentage of electronic equipment has been installed to give control of the drive speed of all or part of the machine.

Nearly all machine tool drives fall into one of two classes: spindle drives, and feed drives. The spindle drive, in general, is that which supplies power for removing metal and is a constant horsepower application. The feed drive includes the individual drives used to position slides, tables, carriages headstocks, and other moving elements of machines. These are primarily friction loads and hence are constant torque applications. A number of specific applications of both types of drive were described, with emphasis on the importance of simplicity both in design and operation of the electronic devices.

Some of the problems of controlling the speed of industrial conveyors were discussed in a paper, "The Use of Electronics for Materials Handling Systems," by S. W. Jessop, Jervis B. Webb Company. Both overhead conveyors and floor conveyors were described. The overhead conveyors consist of trolleys suspended from an I beam on the ceiling and moved by a chain drive. Floor conveyors are of a variety of types and usually combine the carrying function with some other process such as painting, inspection, packing, and so forth. Production requirements often demand a wide speed range for the conveyors and they must be synchronized in various parts of the plant to insure a uniform flow. In large conveyor systems, d-c drive is often not good because of the drop in speed as the system gets fully loaded and because of union objections if the speed of the system is speeded up only slightly. Mr. Jessop described a conveyor drive using a combination of servo motor and one electron tube to control an induction motor. Precise control of conveyor speed can be achieved, and the a-c system has the advantage that it can be operated with occasional manual control if the electronic control should fail.

A process for machining metals by means of an electric spark was described in a technical paper, "Theory of Electric Spark Machining," by E. M. Williams, Carnegie Institute of Technology. In this process, a succession of high current sparks are caused to pass between the work piece and an electrode. The gap is immersed in a dielectric such as kerosene or transformer oil and material is removed from both work and electrode. The process permits rapid and accurate cutting of hard alloys of titanium, zirconium, vanadium, and so forth which ordinarily are not machinable.

The final paper of this session was a technical paper named "Tests of Electrostatic Control for Hazardous Industrial Applications" by Robin Beach which was presented for discussion only.

Session on Electronic Instruments. Newly developed electronic instruments were discussed in the Tuesday morning session over which Rudolf Feldt, Allen B. Du Mont Laboratories, Inc., presided. The first paper, "Over-Temperature Monitor for Multiple Thermocouple Systems," was given by M. Martens with F. H. Bayhi and M. L. Greenough, all of the National Bureau of Standards, as coauthors. This instrument is capable of scanning 48 thermocouples within 5 seconds and if any one is above a certain temperature, an alarm is sounded or a lamp is lit. A meter calibrated in degrees can be plugged into any one of the 48 circuits. Copper constantan or iron constantan thermocouples can be used and corrections are made for their difference in characteristics.

"An Electronic Peak Reading Kilovoltmeter" was presented by R. E. Brueckmann of the National Bureau of Standards. The primary use of this meter is for the measurement of the high voltages encountered in medical X-ray equipment. Readings can be made during exposures in the short time of only 1 cycle, if necessary. Because of this short time, the reading persists on the meter until it is reset.

G. H. Friedman, Franklin Institute Laboratories, gave "An Elliptical Polarization Synthesizer." In the study of the ionosphere elliptical waves of low frequency are used, these being transmitted into the ionosphere and their reflections studied. This synthesizer employs a cathode-ray tube on which Lissajous figures are set up and polarization-planes' patterns are measured along with the voltages.

The next paper was given by R. E. Jones, Ionosphere Research Laboratory, Pennsylvania State College, entitled "A System for Measuring Change of Phase Path of Pulsed Radio Signals Vertically Incident on the Lower Ionosphere." In this method 2.4-megacycle signals are transmitted and the changes in phase or phase paths are observed at a second station 5 miles distant from the transmitter, which also sends out a 50-kc probing signal directly to the receiving station, where the two sets of signals are displayed on a cathode-ray tube in a Z-axis scope.

The final paper of the session, "Measurement of High-Frequency Speed Variation in Rotating Equipment," was presented by E. G. Manning, North Carolina State College. Speed variations found by a tachometer or by stroboscopic means are unreliable. A single-pole generator with a solid disc armature was built and this was coupled to a piece of rotating equipment whose variations in speed were to be measured. An a-c and a d-c output are available; the d-c output is a measure of the speed and the a-c components indicate the variations from 2 to 125 cycles. These can be displayed on a vacuum-tube voltmeter, a cathode-ray tube, or a wave analyzer and can be recorded on a Brush recorder.

Session on Mechanism of Communication. The session devoted to The Mechanism of Communication was held on Tuesday afternoon, January 22, with L. G. Abraham, Bell Telephone Laboratories, Inc., presiding. Three conference papers were presented, the first of these being "Humanizing the Technical Speech," by O. J. Drake and G. R. Sargent, New York University. The authors emphasized that a speaker must analyze his audience carefully before delivering a speech—oral communication is an experience in human relations. They went on further to enumerate ways in which speeches can be made more human: do not try to cover too much ground; give listeners an idea of the purpose of the speech; illustrate where possible; use language that will be understood by everyone listening.

"Writing Visually," by E. L. McAdam, Jr., New York University, was the second conference paper presented at this session. Mr. McAdam stated that analogies are the center of writing visually, and he illustrated the good and bad use of them by reading examples from a newspaper. Points to remember about good analogies are: simple images; significant qualities must stand out; analogy should be stated directly and clearly; do not vary analogy within the text. Always the needs of the readers must be kept in mind and then choose appropriate analogies.

B. M. Oliver, Bell Telephone Laboratories, Inc., presented the third paper, entitled "Exploitation of Message Statistics." This paper covered several important aspects of modern communication theory, particularly those relating to the statisti s of messages and the manner in which these statistics may be utilized in reducing the channel capacity required for the trans-

mission of these messages. Several types of encoding and decoding methods were presented which have the property of using short codes for probable combinations of symbols in the message and longer codes for improbable combinations. These coding methods are applicable to messages of widely different character, for example, English text and television.

Instruments and Measurements. J. G. Reid, Jr., National Bureau of Standards, presided over a Tuesday afternoon session in which two technical papers and three conference papers were presented on various aspects of instruments and measurements.

First on the program was a technical paper entitled "Overload Protection of A-C Instruments" by Wilson Pritchett and Elazar Trau, both of the University of California. In the absence of both authors, the presentation was made by D. F. Morison. The paper described a small magnetically operated device which will short-circuit the current coils of a portable electric instrument in the case of an overload. The protector is small enough to be installed inside the meter case and has been particularly useful in reducing instrument damage in a student laboratory.

"A 10-Cycle to 10-Megacycle Gain and Phase Angle Measuring Set" was the title of a technical paper by F. B. Anderson of the Bell Telephone Laboratories, Inc. This instrument was developed to provide a quick and reasonably accurate measuring device to aid in the design of feedback amplifiers. It can measure transmission magnitude from -18 to $+68$ decibels and phase shift from 0 to 180 degrees. Indications are continuous and are read directly from two meters and a gain dial.

L. T. Fleming, National Bureau of Standards, presented a conference paper, "A Barium Titanate Accelerometer." The device described consists of a small washer of barium titanate which is mounted against a small mass. When the unit is vibrated, the acceleration of the mass produces a piezoelectric effect in the barium titanate which is a good measure of the acceleration. The device has a sensitivity of about 60 millivolts per g (acceleration of gravity), weighs 150 grams, and requires only a high-gain amplifier as an accessory. It has a wide operating frequency range and is extremely rugged, but its chief advantage is the very low cost at which it can be produced.

Various aspects of shore-based radar installations for harbors were discussed in "Shore-Based Radar for Harbor Surveillance" by E. J. Isbister and W. R. Griswold of the Sperry Gyroscope Company. Shore-based radar, now being installed in many harbors both in the United States and in Europe, is the most suitable because no costly installations are required aboard ships. A central radar installation overlooking the harbor facilities keeps watch over all traffic in the harbor, and the radar operator keeps track of ships via radio. As the cost of operating an average size freighter is in the order of $200 an hour, such a harbor installation is economically feasible. The installation of the radar facilities is a routine problem: the difficulty lies in establishing operating procedures and communications. This problem, of course, depends on the size and traffic in the harbor.

A short movie was shown depicting the radar facility now being installed in New York Harbor. This harbor, the largest in the world, has a long narrow channel leading from the ocean to the docking facilities and the channel carries a tremendous volume of traffic. The radar installation covers this traffic and ships can be guided in even during foggy weather, as the pilot is in contact with the radar operator by means of a small portable transceiver which he carries aboard the ship.

Basic Sciences. Professor M. G. Malti, Cornell University, presided over a Wednesday morning session in which one conference paper and four technical papers on a variety of subjects were presented.

The conference paper was "Self-Generated Oscillations in the D.C. Carbon Arc" by B. H. List and T. B. Jones of The Johns Hopkins University. It described an effort to determine the cause for oscillation in welding arcs, and the carbon arc was studied as it is most stable and lends itself more readily to measurement than other types of arc. The authors studied the relationship of the arc's light output from the anode and the voltage across the gap. It was found that the arc spot on the anode moves in a circular path and that this movement is related to the oscillation and to arc hissing.

A. D. Moore, University of Michigan, spoke on "Mapping Techniques Applied to Fluid Mapper Patterns," describing a simple graphical technique for evaluating a regular array of curvilinear lines such as a field map. The method consists of drawing circles within the lines of the pattern to construct curvilinear squares. Tubes made up of these squares then can be evaluated either in relative terms or in terms of actual resistance, voltage, or other quantity to give a rather accurate quantitative analysis of the pattern. Professor Moore also demonstrated his fluid mapper which provided the field pattern to be analyzed.

"Electromechanical Analogies of a Separately Excited D. C. Machine" by R. E. Vowels and W. G. Forte of the University of Adelaide, Australia, presented an equivalent circuit or electric analogue of a shunt d-c machine. The analogies developed are expected to be useful in the study of machine vibration problems involving the stator and rotor. By the use of feedback, it should be possible to modify the mechanical constants of the system to vary the time of response and general performance.

A mathematical paper, "Equations for the Inductance and Short-Circuit Forces of Busses Comprised of Double Channel Conductors" by C. M. Siegel, University of Virginia, and T. J. Higgins, University of Wisconsin, gave the derivation of equations for determining the inductance and the short-circuit forces in terms of bus dimensions for single- or 3-phase busses of the type made up of two separated channels located flange to flange.

The final paper of this session was "Wave Filter Characteristics by a Direct Method," by R. C. Taylor and Mrs. C. U. Watts of the Western Union Telegraph Company. By means of this method filter attenuations for the seven most common ladder filter sections can be read from a single chart or, more conveniently, from two charts. Many properties of low-pass, high-pass, and band-pass filters are deduced readily by inspection.

Electron Emitters. Recent developments in electron emitters was the subject of the Wednesday morning session over which L. S. Nergaard, RCA Laboratories, Princeton, N. J., presided. The first paper was presented by A. M. Bounds and P. N. Hambleton, Superior Tube Company, and was entitled "The Nickel Base Indirectly Heated Barium Oxide Cathode." After discussing the different types of cathodes and their use in various types of vacuum and gas tubes, the author considered the reducing elements: magnesium, silicon, titanium, and carbon, and how they are employed. He stressed the fact that many apparent weaknesses of the oxide cathode stem from its misuse and a lack of understanding of its characteristics.

W. P. Bartley and J. E. White, General Electric Company, presented "Characteristic Shifts in Oxide Cathode Tubes." It is thought that a high-resistance layer at the interface between the base metal and emissive oxide is produced by the chemical reactions of impurities in the cathode base nickel with the emissive coating. The interface layer acts like a resistor with a small capacitance across it in series with the cathode and it is capable of shifting the static control characteristics. This shift with time of service was found to occur primarily due to changing contact potential difference. Interface resistance is a major effect after a few hundred hours in active cathode tubes but stays negligible up to about 3,000 hours in tubes with passive cathodes.

"Lanthanum Boride Cathodes" was presented by J. M. Lafferty, General Electric Company. Among other properties of these cathodes, their electron emission is greater than that from thoria; they are useful in applications where high current densities are required and in high-voltage applications as they stand up well under positive ion bombardment; they are stable and require no activation.

The final paper in the session, "Further Developments in the Structure and Methods of Fabricating L-Cathodes," was presented by O. G. Koppins, R. Levi, and J. Lambertson, Phillips Laboratories, Inc. The original L-cathode was made by welding a porous tungsten disc to a molybdenum cup; this welding has been eliminated by embedding the emissive material in the porous tungsten. By using a special barium emissive material, better life can be obtained than by use of a barium-strontium carbonate pellet. Several types for magnetron application were described with their emission characteristics and were of the directly and indirectly heated types.

Session on Safety. Four conference papers covering various phases of safety were presented in the session held on Wednesday morning, January 23, over whic Hendley Blackmon, Westinghouse Electrich Corporation, presided.

The first paper, entitled "Organizing for Effective Accident Prevention," presented by H. J. Crisick, Cleveland Electric Illuminating Company, gave a description of accident prevention activities in the author's company. In 1948, alarmed by the rising injury frequency rate, the company embarked upon a safety program and three years later

had attained a 72-per-cent reduction below its 5-year average frequency rate, and a rate 58 per cent below that of the electric utility average. The plan of organization used by the company to achieve these results was outlined by the author.

"Some Fundamental Principles for Safe Electrical Design of Appliances" was the title of the second paper, which was presented by G. E. Schall, Jr., and W. C. Walsh, both of the Underwriters' Laboratories, Inc. The authors listed and discussed in detail the basic considerations which are paramount factors in the design of safe electric equipment. They are: rating; supply connections; grounding provisions; normal heating; dielectric strength; insulation resistance; abnormal heating; constructional features; and marking.

The third paper, "Brief Review of European Electrical Safety Requirements," by Frank Thornton, Jr., consulting engineer, Pittsburgh, Pa., was read by R. C. Sogge, General Electric Company. Each European country has a program of standardization and safety testing and the International Commission on Rules for the Approval of Electrical Equipment, which is composed of representatives from 13 different countries, is engaged in developing specifications to be recommended to the individual countries for enforcement by their own inspection authorities. This activity is important as it contributes to the lowering of trade barriers among the European countries.

H. H. Watson, General Electric Company, presented his paper, "Report on Trends in the Revisions of the National Electrical Code," which explained how and by whom the code is drawn up and what the real purpose of the code is. Mr. Watson pointed out that the code claims only to be a minimum standard for safeguarding the public and property from electrical hazards. If this is understood clearly much misuse and criticism will be cleared up. A few expected changes and additions to the next code were given.

Color Tubes for Television Session. Advances in the development of receiving tubes for colored television were discussed on Wednesday afternoon in a session over which W. R. G. Baker, General Electric Company, presided.

H. B. Law, RCA Laboratories, presented the first paper, "A Three Gun Shadow Mask Color Kinescope." After defining some of the terms pertaining to spectral color, such as hue, value, saturation, and how the mixing of primaries was an additive process, the speaker demonstrated how in this new tube the mixing of colors on the tube's screen resulted from juxaposition instead of superimposition of the color dots. He then told about the tube's physical construction, manufacturing, and functioning.

"Color Phosphors for Television" was given by A. Steadman, Allen B. Du Mont Laboratories, Inc. Two main problems exist in the selection of phosphors used on the screen of color television receiving tubes: the maintenance of their color-emitting properties over a period of time and the rate of light decay after excitation by the electron beam. Sulphides are rather difficult to prepare, but phosphates and silicates can be prepared for use in the necessary fine sizes—about 0.7 micron—for application to the glass screen.

Robert Dressler, Chromatic Television Laboratories, Inc., gave a paper on "The Chromatron—A Single or Multigun Cathode-Ray Tube." The phosphors of this tube are applied to the screen in vertical strips with those emitting red and blue light twice the width of those emitting green. The electron beam must pass through a system of parallel stainless-steel wires before arriving at the screen and it is on these wires (divided into two sets) that the red and blue signal voltages terminate. There are 84 strips of phosphors per inch, which are applied by the silk-screen printing process. In the 3-gun tube, the phosphor strips are of equal width.

The final paper of the session, "Colorimetry in Television," was presented by F. J. Bingley, Philco Corporation. It is essential that television engineers now know the mathematics of colorimetry. Any colors can be represented by X, Y, and Z and three reproducing primaries are practical for color television. Any color can be designated by the equation

$$P=lX+mY+nZ$$

where l, m, and n are constants and

$$T=X+Y+Z$$

is the color package or the total tristimulus value. There has been adopted a standard mathematical package of this nature for color television.

Education Session. The session on education held on Wednesday afternoon, January 23, was presided over by H. N. Muller, Jr., Westinghouse Electric Corporation. Three conference papers were presented.

The first paper, "The Objectives of Graduate Engineering Education—An Employer's View," was by William Oncken, Jr., United States Navy Bureau of Ordnance. He described the professional development program which the Bureau of Ordnance has instituted and listed the professional attributes that the Bureau considers important for candidates to have or to acquire. Graduate education is a vital part of this professional development program and can help candidates develop some of these attributes.

E. R. Gaty, Philadelphia Electric Company, presented a paper entitled "Objectives of Graduate Education as Seen by the Public Utility," in which he stated that although an advanced degree is not needed to solve the day-to-day problems of the power industry, graduate education can help superior students develop their abilities to the fullest extent, although sometimes it is advisable for an engineer to wait until after he has worked for two or three years before going on in his education. Mr. Gaty stated that there are limited places for the pure scientist in the electric power industry.

"Specific Objectives of Electrical Engineering Curricula" was the title of the paper presented by E. A. Walker, Pennsylvania State College. He reviewed some of the strongest criticisms of engineering curricula: that not enough humanities are taught in engineering schools; not enough fundamentals are taught; and that there is too much specialization. Mr. Walker showed what has been done to correct these faults and gave an outline of future plans designed to further improve engineering education.

New Techniques in Facsimile. A well-attended session devoted to modern facsimile techniques was presided over by A. G. Cooley, Times Facsimile Corporation, on Wednesday afternoon. One technical paper and four conference papers were presented.

M. Alden of Alden Products Company gave the first conference paper in which he discussed some of the design aspects of high-speed facsimile devices with particular attention to machines for internal business communication. Such machines must be economical, easy to use with little or no instruction, have no adjustments that the operator must make, and have little maintenance. A machine essentially fulfilling these requirements was described. It is capable of transmitting a full letter page in 1/2 minute and has a complete transmission cycle of 38 seconds within a 15-kc bandwidth. Unit construction is used throughout so that very little time need be lost due to circuit failure.

A facsimile system capable of sending 80 complete standard size letters per hour was described in a technical paper, "A High-Speed Direct-Scanning Facsimile System" by C. R. Deibert, F. T. Turner, and R. H. Snider, all of the Western Union Telegraph Company. Both the transmitter and receiver of this system use direct scanning, making the transmitted message available immediately at the receiving terminal. Servo loops around the 1,800-rpm scanning motors provide the synchronous precision required at the high speeds involved. Phasing is accomplished by controlling the phase of the motor driving voltage at the recorder. The equipment is automatic and is under the complete control of the sending operator.

The two following papers described the transmitter and receiver of this high-speed system separately. D. M. Zabriskie, Western Union Telegraph Company, discussed the receiver operation and circuits. Because of the high speeds used, the receiving apparatus must be fully automatic, and the receiver operator must be able to read the signal as it is being reproduced. To accomplish these two requirements, the receiver records the message on a long roll of teledeltos paper, and the message is cut off the roll automatically when the end of message signal is received. Two of these receiving machines are used at each installation so there is no time lost when the roll needs to be changed or if a fault occurs in one receiver. Switchover is automatic.

The transmitter, described by L. G. Pollard of Western Union Telegraph Company, presents the problem of handling the message blanks at the high operating speeds. This was solved by using a transparent plastic cylinder rotating at the scanning speed of 1,800 rpm. The message is placed inside the cylinder and centrifugal force holds it in place against the cylinder walls. A carriage mounting a lamp, optical system, and photocell travels the length of the cylinder at a uniform rate to scan the inside surface of the cylinder.

The subject of the final conference paper of this session was the Desk-Fax transceiver, presented by G. H. Ridings and R. J. Wise of the Western Union Telegraph Company. This little unit is a self-contained telegraph instrument, small enough to be located conveniently on a desk, and

it produces facsimile copies of telegrams. It is used for terminal handling of telegrams between business houses and the nearest Western Union main office. One of the chief design requirements for the Desk-Fax was that it must be simple enough "even for the boss to operate."

To send a message, the patron puts the typed or handwritten message on a small cylinder on the front of the machine and pushes the "send" button. The main office picks up the call and starts transmission with a line signal, and the machine shuts itself off at the end of the message.

Receiving is equally simple. Upon hearing a buzzer call, the customer puts a teledeltos receiving blank on the drum, pushes the "receiver" button, and subsequently acknowledges receipt of the message by pressing the "accept" button. No further action is required except to remove the teledeltos paper. The drum rotates at 180 rpm with a line feed of about 130 lines per inch. The transmission time required to handle a full-size message (8 by $4^1/_2$ inches) from the Western Union office is 2 minutes and 20 seconds. The transceiver generates a carrier of 2,400 cycles per second modulated at a maximum rate of 1,000 cycles by the copy. It draws about 150 watts from the a-c line during operation and nothing while it is idle. The a-c power at the two ends of the circuit must be synchronous for proper operation.

Digital Computers. Some new developments in storage circuits and the use of transistors in computing machines were covered in four conference papers presented on a Thursday morning session presided over by W. H. MacWilliams, Jr., Bell Telephone Laboratories, Inc. The session drew a large attendance and much interest was shown in the four papers.

"Three-Dimensional Magnetic Storage" was the title of the first paper, presented by J. W. Forrester, Massachusetts Institute of Technology. It was pointed out that many methods of storing binary information are available, especially if high-speed access to the information is not required. When rapid access is required, switching becomes the greatest problem. Mr. Forrester described a special magnetic core made of ceramic material and having three windings such that information is either stored or released from one winding upon proper excitation of the other two windings. The actual cores are toroidal and are only about 1/4 inch in diameter. These are woven together in a netlike arrangement in such a way that any core can be located by energizing two input leads to the net. This 2-dimensional arrangement can be extended easily to a third dimension simply by weaving the net in three dimensions.

"Ferroelectric Materials as Storage Elements for Digital Computers and Switching Systems" by J. R. Anderson, Bell Telephone Laboratories, Inc., was the second paper of the session. The materials described are dielectrics in which the dipoles align themselves, and they exhibit a dielectric strength versus applied voltage curve which looks like the hysteresis loops of magnetic materials. A capacitor using the material as a dielectric can be used as a storage element because the capacitor will exhibit a high capacitance if it is storing a charge, and a low capacitance if it is not storing a charge. The ratio of maximum to minimum capacitance can be made as high as 50 or 60, and the charge can be stored for about a week. A 2-dimensional storage system can be made by using a slab of the material. A number of parallel electrodes on one side of the slab are placed perpendicular to a similar number, also parallel, on the opposite side. The space between any two crossing electrodes serves as the storage unit, and the stored information is easily reached by switching to the correct pair of electrodes.

W. E. Mutter, International Business Machines Corporation, gave a paper titled "An Improved Cathode-Ray Tube for Application in Williams Memory Systems." Any cathode-ray tube will work as a storage element in the Williams system, but by designing the tube specifically for this application much better performance can be attained. The tube described, designated as *IBM-79*, is similar to the type *3KP1*, but has a much higher deflection sensitivity. In the construction of such tubes, extreme cleanliness is required and the tube screen must be free from spots. Many spots are caused by dust and can be removed after evacuation by inductively charging them with a Tesla coil and repelling them from the face of the tube electrostatically.

A paper entitled "Catalog of Computer Design" was given by J. H. Felker, Bell Telephone Laboratories, Inc., in which some of the modern trends in computer designs, especially the use of transistors, were discussed. Transistors cannot put out as much power as vacuum tubes, but they do put out enough to operate relays in computer circuits, and they have the tremendous advantage that they operate on practically no power. A 16-digit serial multiplier was cited which has 40 transistors and operates on only $5^1/_2$ watts. Besides the obvious advantages of small size and high efficiency, transistors also increase the reliability of other components in the computer because of the resulting lower operating temperatures. The most effective use is made of transistors if serial rather than parallel computation is used and if diode logic circuits are used for the actual computation and the transistors are used only for amplifying. It also was suggested that transistors could be used for large-scale memory units in which they would drive acoustic delay lines.

Session on Electron Tubes. Various phases of electron tube design and operation were the subjects considered at the Thursday morning session with J. T. Thwaites, Canadian Westinghouse Company, Ltd., presiding.

The sole technical paper of the session was presented by title only: "Tubes for Dielectric Heating at 915 Megacycles" by R. B. Nelson, General Electric Company. Dr. W. G. Dow explained some of the interesting points of the tube, which was described in *Electrical Engineering*, July 1951, pages 627–33.

The first conference paper was presented by T. H. Rogers, Machlett Laboratories, Inc., entitled "A New Rectifier Tube for Extremely High Power and Voltage Levels." After reviewing the rectifier-tube principles, the author described the design of high-current rectifiers. One of the interesting developments in the new tube is a type of catenary filament which was designed to resist the mechanical stresses set up by the electrostatic field within the cathode structure. In the discussion following this paper's presentation, it was brought out that here was an example of how it pays to take a second look at something already considered a finished product.

R. B. Ayer, Radio Corporation of America, presented "High Power Industrial Vacuum Tubes with Thoriated Tungsten Filaments." The use of a thoriated tungsten filament in tubes provides a higher emission of electrons with 500 or 600 degrees lower operating temperature. The loss of the monatomic layer of carburized thoriated tungsten around the tungsten core results in a drop of emission to a very low value. The maximum operating temperature should not be exceeded; for example, a tube life of about $3^1/_4$ times at 1,950 degrees Kelvin is obtained over the maximum temperature of 2,000 and the life is only one-third as long at an operating temperature of 2,050 degrees Kelvin. One of the important factors in manufacturing is cleanliness and another is outgassing in 100-kw tubes.

The next paper of the session, "The Influence of a Transverse Magnetic Field on an Unconfined Glow Discharge," by W. G. Dow and W. D. McBee, University of Michigan, was presented by the latter. The influence of various magnetic fields on the discharge between two electrodes was illustrated by a series of colored slides of photographs made under varied conditions of voltage. They showed how the trajectories of electrons were affected by the magnetic fields and it was brought out that the electrons follow equipotential lines.

The final paper was given by J. A. Goetz and A. W. Brooke, International Business Machines Corporation, entitled "Electron Tube Experience in Computing Equipment." This paper outlined the methods of testing vacuum tubes for computer use and their findings. (See February 1952 issue of *Electrical Engineering*, pages 154–7.)

Mobile Radio Systems Session. Problems of design and operation of mobile radio systems were considered in the Thursday afternoon session over which A. C. Dickieson, Bell Telephone Laboratories, Inc., presided.

G. E. Dadrill amplified the report by the Committee on Radio Communications Systems entitled "Lightning Protection of Base Stations in the Mobile Radio Service," which was published in *Electrical Engineering*, January 1952, pages 73–75.

The next paper by A. R. Vallarino and S. W. Lewinter, Federal Telecommunications Laboratories, Inc., "A Radio Dispatching System for Large Taxicab Fleet Operation," is published in this issue of *Electrical Engineering*, pages 232–35.

The last paper of the session, "Radio Communication Equipment AN/GRC-3 through 8," was by J. H. Durrer and David Talley, International Telephone and Telegraph Corporation, and was presented with demonstration of the equipment by M. C. Poylo, Signal Corps Laboratory, Fort Monmouth, N. J. This versatile frequency-modulated equipment has been adopted for use by the three branches of the armed services. It is a standardized series of units operating between 20 and 55 megacycles which can be used separately or in combination to perform different functions.

One unit in a jeep, for instance, can be employed as a relay transceiver with a walkie-talkie and it can connect the walkie-talkie with a command post. Also it could be connected to a telephone line for long-distance communication. One transceiver unit covers the range between 38 and 54 megacycles and uses only 14 crystal oscillators; the double superheterodyne circuit is used in each of the equipment's receivers. The equipment consists of a transceiver, auxiliary receiver, a 0.5-watt receiver-transmitter, a mixer for three audio-frequency channels, a remote-control unit, and the 12- or 24-volt storage-battery power supply. The total weight is 250 pounds.

Conference on Energy Sources. Two conference papers on the effects of natural phenomena on communications were presented in a Thursday afternoon meeting presided over by L. W. Matsch, Illinois Institute of Technology.

O. B. Jacobs and J. J. Gilbert were co-authors of the first paper which discussed the effects of magnetic storms on underground and submarine communication cables. These storms seem to be caused by large differences in magnetic potential between various points on the earth's surface and apparently they are related to the occurrence of sun spots and to auroral displays. Disturbances on ocean cables cannot be predicted from sunspot observation, but in northern latitudes disturbances always occur during magnetic storms. The conversion of ground-return telegraph circuits to metallic return has reduced the effects of magnetic disturbances greatly.

Very great interest was shown in the paper "Sunspots and Planetary Effects Upon Radio Signals" by J. H. Nelson of the RCA Laboratories. After many years of observing radio transmission data, sun spots, and planetary motion, Mr. Nelson concluded that something besides the occurrence of sunspots was responsible for interference with short-wave communications on earth. He discovered that the positions of the planets seem to correlate with radio interference, and in particular that certain configurations of several planets occur when interference is the worst. Interference is most severe when two planets are at 180 degrees with each other and a third is at 90 degrees with both. Other 0-, 90-, and 180-degree configurations of three or more planets may also cause increased radio interference.

Last year, for example, Jupiter and Saturn were at 180 degrees with each other, and Uranus was at 90 degrees. Since all three of these planets move only a few angular minutes per day, the configuration lasted throughout most of the year, and 1951 was a particularly bad year for short-wave radio communications. The smaller planets closer to the sun move faster and therefore may cause interference peaks more frequently. By predicting the occurrence of these planetary configurations, it has been possible to predict the occurrence of radio interference with a surprising degree of accuracy, although occasionally a "negative" interference peak occurs. In this case radio interference is unusually quiet.

A physical explanation of this phenomenon is not yet possible, but the suggestion has been advanced that radio interference is the result of tidal effects in the outer layers of gases on the sun. The two planets spaced 180 degrees cause tidal bulges on opposite sides of the sun, but the third planet tries to pull in opposition to these bulges. The resulting forces cause electrical disturbances which create large currents in the earth's ionosphere. These currents, also believed to be responsible for the magnetic storms described in the previous paper, are thought to be the cause of radio interference.

Session on Industrial Power Systems. The power systems for three different types of installations were covered in the session over which H. G. Barnett, Westinghouse Electric Corporation, presided.

The first paper, "Electric Power Supply for a Large Chemical Plant" given by A. C. Friel of the Dow Chemical Company and J. P. Smith, General Electric Company, outlined the difficulties of distribution of power in the Midland plant of the Dow Chemical Company where a portion of the power is generated by the company and a part purchased from a local power utility.

"Electrical Systems in the Port Authority Bus Terminal" was presented by W. Henschel and H. W. Wenson, Jr., of The Port of New York Authority. This new $24,000,000 building, serving about 2,600 busses and 125,000 passengers daily in mid-Manhattan, has an electric system which may be divided into two parts: one for house and tenant power, including lighting, heating, sprinkler, snow-melting systems, and so on, and the second for communication and signalling systems including public address, clock, bus dispatching and counting, fire alarms, and so on. It is expected that the maximum demand will be 3,000 kva; to date the demand has been 1,800 kva, and when all the tenant areas are rented with the imposition of other loads, it is expected that the maximum demand will be about 2,100 kva leaving about 40 per cent for growth in the 50-year expected life of the building.

The last paper of the session, "Electrical Systems for the United Nations Headquarters," was given by F. B. Graham, Syska and Hennessy, Inc. The load of the building group is about 7,500 kw in lighting and office equipment, 8,500 horsepower in motors, and 1,840 kva of miscellaneous load. More than half the motor load represents air-conditioning equipment, whose compressors are steam-driven, steam coming from the New York Steam Corporation. In the Secretariat Building 20 high-speed elevators account for about 1,500 horsepower in connected load. The miscellaneous load includes 1,250 kva of communications equipment.

Feedback Control Systems. Some theoretical aspects of feedback control system design were brought out on Friday morning in a well-attended session. F. W. Herwald, Westinghouse Electric Corporation, presided and two technical papers and a conference paper were presented.

"The Writing of Closed-Loop Control System Transfer Functions by Inspection," by J. B. Flannigan of Sperry Gyroscope Company and H. S. Kirschbaum of Ohio State University, was given first. It presented a simple method for writing transfer functions for closed loop control systems which have but one forward path between the input and output stations, or systems which can be modified to have such a path. The method is easy to apply and has the advantage over a formal solution that errors are less likely to occur. Even in systems where the method does not apply, much labor often can be saved by applying it to parts of the system.

The second technical paper, "Synthesis of Closed Loop Systems Using Curvilinear Squares to Predict Root Location," was by D. W. Russell, Arnold Engineering Development Center, and C. H. Weaver, The University of Tennessee. The paper introduced a procedure for synthesizing servomechanisms whereby the roots of the characteristic equation can be predicted. Given a specified location on the s plane for the roots, the open-loop transfer function parameters and gain can be calculated to give those roots. Especially useful is the ability of this procedure to determine whether a desired transient response is physically possible for a particular system.

The conference paper in this session, by J. F. Koenig of the National Bureau of Standards, was titled "Additions to the Stability Theory and Design of Servomechanisms." A method was presented for obtaining stability diagrams for servomechanisms and other types of feedback systems. Called the dominant root method, the procedure is based on three theorems developed by the author and makes use of three diagrams used jointly in either analysis or synthesis of the system. Each diagram is plotted in terms of three system parameters, holding all other parameters constant. If three parameters vary during system operation the operating point moves in the diagrams. For each position of the point the dominant pair of roots is known. The diagrams show how far the operating point is from instability and also the amount by which three parameters may vary before the dominant roots have changed by any specified amount. The method therefore gives quantitative information for a wide variety of feedback problems.

Symposium on Germanium Rectifiers and Transistors. The six conference papers presented at this Friday afternoon meeting drew a large and interested audience. W. C. Dunlap, Jr., General Electric Company, was chairman of the session and also presented one of the papers.

Some of the fundamentals of this semiconductor were discussed by J. P. Jordan, General Electric Company, in his paper "A-B-C of Germanium" to provide a general background for those with no direct experience in the field. He described briefly some of the sources of germanium, which comes mostly from the residue of zinc smelting processes, although there are a few germanium ore bodies. The germanium is produced by a drawing technique and is a hard silvery material which is very brittle and difficult to work with. It produces no known toxic effect. The conductivity of germanium lies between that of conductors and insulators and therefore it has the name semiconductor. Mr. Jordan described the lattice structure of the single crystals and explained the conduction mechanism in terms of this structure for both the n-type and the p-type germanium.

Mr. Dunlap gave a paper entitled "Conduction Properties of Germanium Single Crystals." These crystals have a conductivity range from 1 to 10^4 which depends

on a number of factors. Curves were shown of the effects of the scattering of impurities within the crystal lattice and the effects of temperature on the mobility of the conducting electrons. Variations of resistance with magnetic field and with temperature also were described. The germanium crystals have rather stable electrical characteristics, although changes in resistivity did occur in crystals which were held at a constant temperature of 100 degrees centigrade over a period of 3 months and some migration of material effects has been noted.

In the third paper, J. A. Morton, Bell Telephone Laboratories, Inc., described some of the electrical characteristics of the new n-p-n junction transistors and developed a relationship between equivalent circuit elements and the physical structure of the transistor. The equivalent circuit was developed by breaking down the transistor into three parts: the emitter, the collector, and the base transport. The resulting equivalent circuit was compared with that of a grounded-grid vacuum tube, to which it shows a considerable similarity.

"Circuits for Junction Transistors" was the title of a paper given by R. L. Wallace of the Bell Telephone Laboratories, Inc. Because engineers are accustomed to using vacuum-tube circuits, it is often convenient to think of the transistor in terms of vacuum-tube circuits, and in fact, the transistor works remarkably well in many vacuum-tube circuits. It makes a good cathode follower, for example, and as an amplifier it can achieve a gain per stage of about 56 decibels. It is particularly useful for working with small voltages and currents and has an amazingly high efficiency. Mr. Wallace demonstrated an audio oscillator circuit which he operated with only the output of a small photoelectric cell of the type used in lightmeters as a source of energy. In case of darkness, the oscillator can be made to operate on a battery consisting of a coin wrapped in a piece of blotting paper wet with saliva. To find a convenient unit of power for this oscillator, the average weight of an ordinary dog flea was determined and, on the assumption that the flea leaps about 50 centimeters every 60 seconds, which is not asking much of the flea, the unit of one fleapower (about 50 ergs per minute) was established. The transistor oscillator will operate for 1 minute on 1 fleapower.

V. Ozerow of the General Electric Company gave the fifth paper of the session in which he described a process for recovering germanium from factory waste. In the manufacture of germanium crystals for electrical use, about 92 per cent of the germanium is lost as waste. About half is lost as sawdust just in the cutting process where purified ingots are cut into thin slices by a diamond saw, and the rest is lost in purification and other processes. Recovery of this waste is not only economical but also permits an independent quality control on the part of the manufacturer and it represents an enormous potential source of supply, although the present natural supply is adequate. The first step in the purification of the waste is chlorination. This produces germanium tetrachloride, which is very similar to carbon tetrachloride, and this is then fractionated or distilled to separate it from impurities. The final step is hydrolysis of the pure germanium tetrachloride to get germanium dioxide. About 80 per cent of the factory waste can be recovered by this method, and it can be done by a semiskilled operator with only casual supervision.

The final paper in the germanium session was by F. J. Lingel, General Electric Company, who discussed a new germanium power rectifier of unusually small size for its capability and suitable for replacing selenium rectifiers in aircraft and portable equipment. A 200-milliampere unit of this type uses a piece of germanium 1/8-inch square and 25 mils thick. This is soldered to a fernico strip and the soldering process produces a p-n junction of exceptionally good rectifying properties. The rectifier has unusually good mechanical strength although it is sensitive to excess heat. Efficiency is good up to about 50 kc.

Insulated Conductors Session. Three technical papers on insulated conductors were presented at a session on the last afternoon of the meeting with C. T. Hatcher, Consolidated Edison Company of New York, Inc., presiding.

A report, "A-C Resistance of Pipe-Cable Systems with Segmental Conductors," was presented by the Working Group of the Cable Characteristics Subcommittee. It is the purpose of this report to present a study of the a-c resistance characteristics of segmental cables installed in steel pipe, covering a practical range of sizes from 1,000,000 circular mils to 2,500,000 circular mils operating at 60 cycles. The data available, which were obtained from a joint research project conducted at the Electrical Testing Laboratories, Inc., and from the laboratories of pipe-cable manufacturers, were studied by the Working Group to establish underlying theory and theoretical or empirical relationships between values of effective resistance which may be calculated in air using accepted equations and values which may be expected in pipe. Working equations for calculation of values in pipe are given in this report.

Mr. R. W. Burrell, Chairman of the Working Group, presented the paper for the Group and Mr. L. Meyerhoff made the closing remarks. Several discussions were read from European engineers to whom preprints of the paper had been sent. The data contained in this report have been needed for a long time and the high cost of these studies was money well spent.

The second paper, "Auxiliary Power and Control Cables for Steam Electric Generating Stations," was presented by F. V. Smith and E. G. Norell, both of Sargent and Lundy. This paper contains a review of the methods of distribution of auxiliary power and control cables in steam stations and outdoor substations and the selection of suitable cables with the characteristics needed for such projects, these being maximum reliability, compactness of design, and conduit or cable pan construction. Data are presented for auxiliary power and control cables for a typical steam-generating station; essential characteristics of cable insulation and covers; and cable practice in typical power stations.

The paper on "Generator Lead Practice" was given by M. J. Lowenberg, Stone and Webster Engineering Corporation. Data were received from a questionnaire sent to 35 utility and engineering companies, describing leads on 209 generators with a total maximum rating of 16,700,000 kva. Analysis of these data indicates a trend to use isolated-phase metal-enclosed bare-copper conductors on generators rated over 60,000 kw either indoors or outdoors where the runs are short. Analyses of both indoor and outdoor installations were presented in tabular form covering bare and insulated cables, the type insulation and covering, and for bare conductors, the type enclosures, and types of barriers between phases.

240 Attend AIEE Conference on Electronic Instrumentation

The fourth annual AIEE Conference on Electronic Instrumentation and Nucleonics in Medicine was held at the Hotel Commodore, New York, N. Y., January 7 and 8, 1952. This series of sessions stressed the medical phases of the subject more than heretofore and the papers presented were of a very high grade. Approximately 240 members and guests attended.

Monday A.M. Session. The first session, over which G. Failla of Columbia University presided, was opened by a description of a phosphor-phototube gamma-radiation detector by Messers Cole, Duffy, Hayes, Lusby, and Webb of the Westinghouse Electric Corporation. This was followed by a paper by P. E. Ohmart, Ohmart Corporation, who discussed a new method of measuring radioactivity in which a cell of two dissimilar materials separated by a filling gas converts radioactivity directly into electric energy. When the filling gas is ionized by exposure to alpha, gamma, or some other radiation, the fact that the electrode surfaces have different work functions cause the positive ions of the gas to flow to the positive electrode and the electrons to go to the negative electrode, producing electric current.

"Fluorescent Crystal Counting in Medical Tracer Research" was presented by H. O. Anger, University of California, who described a scintillation-type gamma counter for liquid or solid samples. E. D. Trout and John Vlach, General Electric Company, discussed the cobalt-60 irradiator for teletherapy and Dr. B. Selverstone of Tufts College Medical School and W. E. C. Eustis, W. S. Macdonald Company, described the localization of brain tumors by scintillation counting.

Monday P.M. Session. H. D. Moreland, Westinghouse Electric Corporation, presided over the afternoon session, the first paper being "Calorimetric Determination of the Energy of X-ray Beams" by J. H. Laughlin, University of Illinois College of Medicine. This paper described the method in which the X-ray beam is absorbed in a thermally insulated lead cylinder, the temperature rise being detected with thermistors. Details of the calibration, irradiations, and evaluation of the flux were given for 400-kv and 22.5-mega-electron-volt X rays.

H. C. Pollock, General Electric Company, presented "High Energy Electron and X-Ray Beams from the 80-Mev Synchrotron," describing how this machine had been provided with a device for extracting the electron beam using an electrostatic deflection method. "Production of Monochromatic

X-Radiation for Microradiography by Excitation of Fluorescent Characteristic Radiation" was given by T. H. Rogers, Machlett Laboratories, Inc., who reported on the exploratory work attempting to establish the factors governing the intensity and degree of monochromaticity of fluorescent X radiation. The final paper of the session was presented by Dr. R. H. Morgan and R. E. Sturm, The Johns Hopkins Medical Institution, and was entitled "A Fluoroscopic Screen Intensifier for Medical Use." This system uses a conventional fluorescent screen, a Schmidt optical system, an image orthicon, a wide-band television amplifier, and a kinescope. This provides a gain in screen brightness of approximately 10,000 times and a gain in optical resolution of about two times.

After an informal dinner, G. A. Morton, RCA Laboratories, Princeton, N. J., opened the evening session, which featured an address and demonstration by Dr. V. K. Zworykin and L. E. Flory of the same laboratories, read by the latter. (For complete text of this paper, see *EE, Jan '52, pp 40–45.*)

Tuesday A.M. Session. Dr. W. A. Geohegan, St. Lukes Hospital, New York, N. Y., presided over the morning session of the second day of the conference. "Wave Propagation in the Living Human Artery" was given by Dr. Milton Landowne, National Heart Institute, Bethesda, Md. A theory of elastometric behavior has been extended to arteries; brief pressure waves have been superimposed upon the ambient pressure in intact human arteries, which waves have been detected by an intra-arterial needle and transducer, enabling the velocity of pressure-wave propagation and attenuation characteristics of the system to be determined over a range of pressures.

Dr. S. A. Weslowski, Tufts College Medical School, and Dr. C. S. Welch, New England Center Hospital, Boston, Mass., described a mechanical heart for artificial maintenance of the circulation, which has been used successfully in experimental animals to replace the function of either or both sides of the heart by maintaining artificially the pulmonary or systematic circulations respectively. This was followed by "Physical Response Requirements of Pressure Transducers for the Reproduction of Physiological Phenomena," by E. H. Wood of the Mayo Clinic.

The final paper of the session, given by Dr. Jere Mede, Harvard School of Public Health, and Arthur Miller, Sanborn Company, Cambridge, Mass., was entitled "Analysis of Viscous and Elastic Properties of the Respiratory System by Electric Circuit Theory and Electronic Measurement Technique." The relationships of the air flow to the pressure difference between the surface of the lungs and the mouth are analogous to the current-voltage relationships in a resistance-capacitance network where the viscous friction of the tubular system of the respiratory tract to air flow corresponds to the resistance and the elastic compliance of the lungs corresponds to the capacitance. In such a system the volume change of the lungs is proportional to that portion of the intrapleural pressure associated with their elastic compliance, while the remainder of the pressure represents the drop due to the viscous resistance. If the rate of flow and pressure is measured by electric transducers, the voltages obtained can be integrated to obtain volume and the required addition or subtraction processes carried out by appropriate electric circuits.

Tuesday P.M. Session. The final session of the conference on Tuesday afternoon had as its chairman Professor Ernst Weber, Polytechnic Institute of Brooklyn, N. Y. The opening paper, presented by Herman Schwan and E. L. Carstensen, University of Pennsylvania, was "The Application of Electrical and Acoustic Impedance Measuring Techniques to Problems of Diathermy." Certain aspects of electromagnetic and ultrasonic diathermy can be evaluated through the electrical and acoustic impedance of body tissues. This process is applied to a study of the problem of localized deep heating. From experimental data it is indicated that ultrasonic diathermy is superior for the purposes of localized deep heating.

"A Monitor of Physiological Variables for Anesthesia and Other Uses" was given by S. R. Gilford, National Bureau of Standards. During anesthesia and surgery, periodic checks are made of blood pressure, pulse rate, and respiratory function of the patient as an index to his condition. The author described an instrument which obtains all this information automatically and presents it as a continuous indication on a multichannel recorder.

Dr. Albert Faulconer, Mayo Clinic, Rochester, Minn., gave "Physiologic Measurements of Interest to the Clinical Anesthesiologist." Attention has lately been directed to the physiologic responses to the drugs and agents used in the field of anesthesiology rather than to the drugs themselves. Many of the responses cannot be estimated accurately and quantitatively by the unaided senses of observers. Fields inviting the services of engineers are the estimation of the state of oxygenation of the blood and other tissues; indicating devices showing the amount of gas respired per unit time by the patient; some means for the continuous indication in pH of the blood and the blood pressure; electrocardiography; a method for the quantitative estimate of blood flow; a means of showing the state of neuromuscular transmission; suitable equipment for presentation of information to be derived from the electrical activity of the brain; and engineering all of these items to a practical point which will enable them to be used in the operating room.

The final paper of the conference was presented by R. G. Bickford, Mayo Clinic, entitled "Instrumentation for the Electronic Control of Anesthesia." (A complete report of this paper can be found in *EE, Oct '51, pp 852–55.*)

C. L. Killgore is addressing the AIEE Chicago Section Meeting on January 17 on circuit-breaker tests at Grand Coulee

Student Tour and Conference Held in Canonsburg, Pa.

The annual Student Tour and Conference of the electrical engineering students of Carnegie Institute of Technology, University of Pittsburgh, Pennsylvania State College, and University of West Virginia was held Monday, January 14, at the Pennsylvania Transformer Company Plant in Canonsburg, Pa. The Tour and Conference were sponsored by the AIEE and the Engineers' Society of Western Pennsylvania.

Approximately 150 students and faculty members of the four schools participated in the factory tour and luncheon. At 2:00 P.M., a Student Conference was held in the Pennsylvania Transformer Company Administration Building.

The technical papers presented in a prize paper competition were: "Ultrasonics in Water," James R. Fisher, Carnegie Institute of Technology, which won the first prize of \$50.00; "Method of Measuring the Dielectric Constant of Gases by the Use of Microwaves," Clarence J. Zohn, University of West Virginia, which won the second prize of \$25.00; and "Electrometers," Frank N. Zic, University of Pittsburgh.

Presentation of prizes was made at the AIEE Annual "Vice-President's Night" Dinner Meeting held Monday evening, January 14, at the Schenley Hotel.

Judges on oral presentation were: William H. Osterle, West Penn Power Company; William Boyd, Aluminum Company of America; and H. H. Wagner, Pennsylvania Transformer Company. Judges on written presentation were: J. S. Brown, Duquesne Light Company; E. Lamberger, Westinghouse Electric Corporation; and J. P. Warner, Consulting Engineer.

Chairman of the Student Conference was Robert Lynch of Carnegie Institute of Technology. Arnold M. Fox, Pennsylvania Transformer Company, was in charge of the luncheon and tour through the Pennsylvania Plant.

C. L. Killgore Speaks at Chicago Section Meeting

At a meeting of the AIEE Chicago Section on January 17, C. L. Killgore, assistant chief designing engineer of the United States Bureau of Reclamation, said that circuit-breaker tests at Grand Coulee Power Plant showed reclosing of circuit breakers tested in 8, 10, and 12 cycles and based on these tests it appears that faster than 20-cycle reclosing is practical and feasible.

Attending the Lehigh Valley Section dinner meeting in Allentown, Pa., on January 11 were, left to right, W. C. Seymour, Section Secretary-Treasurer; Dr. Preston W. Reynolds, guest speaker; J. O. Leslie, Reading Section Chairman; and S. C. Townsend, Allentown Division Manager for the Lehigh Valley Section

Mr. Killgore participated in the tests at Grand Coulee. He told the meeting that the tests did not cause any disturbance on the system and said that on the basis of experience in these tests he thought there should be more field tests of circuit breakers.

The circuit breakers are designed on different principles and have different construction and operating features and these were discussed by Mr. Killgore. Slides of the test oscillograms and of the circuit-breaker operating mechanisms and interrupter units were shown. New techniques for testing circuit breakers and principles for determining the rating of circuit breakers which have resulted from the extensive field test program carried out at Grand Coulee were explained.

Michigan Section Meeting Held in Detroit January 16

"The Co-ordination of Electric Supply and Communications Systems" was the topic at the meeting of the AIEE Michigan Section in the Bell Building in Detroit, Mich., on January 16, 1952. F. E. Sanford, assistant chief electrical engineer of Commonwealth Services, Inc., and W. E. Bloecker of the American Telephone and Telegraph Company pointed out that all co-ordination efforts should be based on the customer's viewpoint rather than that of the interested companies, and they covered the more important possibilities of inductive interference which require attention such as low frequency and noise frequency influence.

It was announced at the meeting that Henry E. Crampton had been appointed Vice-Chairman of the Michigan Section by the Executive Committee to fill the vacancy created by the death of Professor James S. Gault of the University of Michigan. Mr. Crampton is the building and equipment engineer of the Michigan Bell Telephone Company.

Lehigh Valley Section Holds Dinner Meeting in Allentown

About 200 members and guests of the Lehigh Valley Section of AIEE attended a dinner meeting in Allentown, Pa., on January 11. Dr. Preston W. Reynolds, from The Knolls Atomic Laboratory of the General Electric Company of Schenectady, N. Y., spoke on the "Application of Radio-Active Isotopes in Medicine and Biology."

As part of a program to acquaint Student members with the activities of the Section, 28 Student members from Lehigh and Lafayette Universities were present as individual guests of 28 Section members.

Since the AIEE President is no longer able to make personal visits to the various Sections, the Lehigh Valley Section asked President McMillan to record a brief greeting to the Section to be played at Section meetings. President McMillan very graciously did this and now each Section meeting is honored with a personal message from the AIEE President via tape recorder.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

AIEE-ASME Joint Subcommittee on Recommended Specifications for Prime Mover Speed Governing (*M. J. Steinberg, Chairman*). This subcommittee has completed the preparation of recommended specifications for the speed governing of steam turbines driving electric generators rated 500 kw and up (AIEE Standard *Number 600*, May 1949) and of hydraulic turbines driving electric generators (AIEE Standard *Number 605*, September 1950). The subcommittee is currently drafting a specification for the speed governing of internal combustion engines, completion of which will follow extensive field tests which will be the basis for specifying numerical values of performance.

The Power Test Codes Committee of The American Society of Mechanical Engineers (ASME) has worked actively to complete codes for testing speed governing systems of prime movers in accordance with the specifications prepared by the Joint Subcommittee.

Advancements in the art of design, particularly in the field of steam turbines operating on reheat cycles, and revision of AIEE-ASME preferred standard steam turbine-generators require revision of the steam turbine specification AIEE Standard *Number 600*. This will be undertaken following reorganization of committee personnel to effect co-ordination of the specifications for the three types of prime mover.

Power Division

Committee on Substations (*R. C. Ericson, Chairman; K. L. Wheeler, Vice-Chairman; N. G. Larson, Secretary*). During the past year the committee completed one project on the Basic Structural Design of Outdoor Substations which culminated in a paper presented at the 1952 Winter General Meeting.

The questionnaires on "Substation Grounding Practices" have been analyzed and a preliminary report on the findings was given at the Winter General Meeting. Much data on the grounding practices and experiences now prevalent in the industry are given in this preliminary report. The present plan now is that a complete and final report, even including some recommendations as to practices to be followed, will be prepared during this administrative year.

Other projects being worked on by various subcommittees are: supervisory control—a questionnaire is being prepared—basic single-line diagrams for substations, use of repeater fuses in place of reclosing circuit breakers for lower voltage circuits (12.5 kv and less) at substations, safety considerations in substations, and several others still in the discussion stage.

Project Committee on Revision of Standards for Power Relays (*J. R. Linders Chairman*). Since the revision of AIEE Standard *Number C37.1* several years ago work has progressed on a new performance specification for relays. This is a job of considerable magnitude inasmuch as 51 types of relays are recognized in the existing standards. It is the hope of the committee to establish about five basic relay types for which performance specifications can be written. The need for preparation of these performance specifications along restricted lines was urged by the committee, with emphasis to be placed upon optimum characteristics that can be obtained practically with existing relays or with equipment under development.

Project Committee on Relaying Performance of Current Transformers (*W. E. Marter, Chairman*). At the last main committee meeting, there was considerable discussion concerning the accuracy rating of bushing current transformers with particular reference to poor performance on low current taps. It is probable that a redesign of bushing current transformers for 66-kv oil circuit breakers may be proposed which will result in a reclassification from 10L600 or 10L700 to the far less desirable classification of 10L400 for the 1200/5 multiratio transformers. Questions to be investigated include the relative overall accuracy of (1). bushing current transformers supplying burdens including auxiliary current transformers and (2). bushing current transformers individually connected

to separate burdens but each having the lower accuracy classification of 10L400 or less. The possibility also exists of burden reduction through the use of capacitors in the secondary circuit.

Science and Electronics Division

Committee on Electronics (*J. T. Thwaites, Chairman; H. C. Steiner, Vice-Chairman (East); J. D. Ryder, Vice-Chairman (West); D. G. Wilson, Secretary*). The Subcommittee on Electrical Aids to Medicine has joined with the Therapeutics Committee, taking the new name "Electrical Techniques in Biology and Medicine." The Electron Tube Subcommittee aided in the cosponsorship with the Institute of Radio Engineers of a computer conference. Liaison with the Joint Committee on Spectroscopy Nomenclature of the American Society for Testing Materials and with the Society for Applied Spectroscopy has been carried out by the Subcommittee on Infrared Applications to study infrared nomenclature, definitions, and applications. The X-Ray Tube Subcommittee has completed a report on symbols and one on definitions is nearing completion. Full committee status has been given to the Subcommittee on Magnetic Amplifiers. This group presented a progress report on standards at the Winter General Meeting. The Subcommittee on Passive Components is continuing to direct their attention to the problem of passive component classification because of the over-all classification of the finished product or devices.

The Electronics Committee sponsored six technical sessions at the Winter Meeting: two sessions on New Electronic Devices, and sessions on Recent Developments in Electron Emitters, Color Tubes for Television, Semiconductor Amplifiers, and Dielectric Amplifiers.

Joint Subcommittee on High-Frequency Measurements (*E. P. Felch, General Chairman; R. W. Lowman, Secretary*). The question of preparing a bibliography on high-frequency measurements was discussed at a recent meeting of the committee. While the value of such a project was recognized, it was agreed that the large amount of effort involved in its preparation could not be justified at this time.

It was agreed that many of the objectives of a bibliography might be attained through presentation and publication of a coordinated series of tutorial papers. Some of these might be presented most appropriately at the AIEE-Institute of Radio Engineers (IRE) High-Frequency Measurements Conference in January 1953. This might be followed by publication in the Societies' Journals. More definite plans will be discussed at the next meeting early in March.

The committee is supporting the AIEE-IRE-Radio Television Manufacturers Association Symposium on Progress in Quality Electronic Components to be held in Washington May 5 to 7, 1952.

AIEE PERSONALITIES.....

E. C. Koenig (AM '44), motor-generator design section, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been awarded the Alfred Noble Prize for 1951 for his paper "An Electric Analogue Computer Using the Photo Cell as a Non-Linear Element." The prize was presented to him at the AIEE Winter General Meeting. He was born in Marissa, Ill., on October 11, 1919, and was graduated from Washington University in 1943 with a bachelor of science degree in electrical engineering. He received a master of science degree in electrical engineering from the Illinois Institute of Technology in 1949. He joined the Allis-Chalmers Manufacturing Company in 1943 as a test engineer on equipment for the atomic diffusion plant. After the end of World War II, Mr. Koenig was transferred to the Electrical Department where he is still employed.

E. C. Koenig

O. W. Titus (AM '29, F '44), general manager, Canada Wire and Cable Company, Ltd., Toronto, Ontario, Canada, has been appointed Vice-President of the company. Mr. Titus also will continue as general manager of all operations of the company. A graduate of the University of Toronto, Mr. Titus began his career as sales engineer for the Standard Underground Cable Company of Canada, Ltd., a predecessor of the Canada Wire and Cable Company. In 1929 he became cable engineer for the company and in 1935 was made chief electrical engineer in charge of all design and development engineering for all classes of power cable. Mr. Titus is a member of the Engineering Institute of Canada and the Association of Professional Engineers of Ontario. He is a very active member of the AIEE, having served the Institute on the following committees: Technical Program (1940–41); Public Relations (1950–51); Power Transmission and Distribution (1943–46); and Insulated Conductors (1947–48).

O. W. Titus

F. D. Knight (M '25, F '50), Vice-President, Hartford Electric Light Company, Hartford, Conn., has retired. He will be retained as operating consultant. Mr. Knight was graduated from the University of Maine with a bachelor of science degree in electrical engineering in 1909, and received an honorary doctor of engineering degree in 1950 from the University. He began his career in 1909 with Stone and Webster Engineering Corporation, and was associated with that corporation until 1925 at which time he was superintendent of construction. In 1925 he joined the Boston (Mass.) Edison Company as superintendent of construction and held that position until 1941 when he became Vice-President of the Hartford Electric Light Company in charge of engineering, production, distribution, and construction for the company. He is a member of The American Society of Mechanical Engineers. He served on the AIEE Safety Committee (1930–39, Chairman 1934–35).

R. W. Atkinson (AM '09, F '28, Member for Life), chief research engineer, General Cable Corporation, Bayonne, N. J., has been elected Director of Research. Mr. Atkinson received a bachelor of science degree from Iowa State College in 1906 and his electrical engineering degree in 1911. From 1906 to 1908 Mr. Atkinson was associated with the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation). In 1908 he joined the Standard Underground Cable Company (now the General Cable Corporation) as assistant to the chief engineer, and in 1923 he became chief electrical engineer. Mr. Atkinson is an active member of the Institute, having served on the following AIEE committees: Power Transmission and Distribution (1919–30); Research (1933–41). He is currently serving on the Standards and Board of Examiners Committees.

Earle Wild (AM '27, F '51), power supply superintendent, Commonwealth Edison Company, Chicago, Ill., has been appointed manager of power supply. Mr. Wild entered the employ of Commonwealth Edison in 1924 and has been directing load dispatching work for the past few years. During World War II Mr. Wild served the War Production Board as power co-ordinator for the New England and other east coast states. Mr. Wild is a member of the Western Society of Engineers. He is an active member of the AIEE, having served on the following Institute committees: System Engineering

(1947–50, Chairman 1948–50); Power Co-ordinating (1948–50); Standards (1948–50); Technical Program (1948–50).

R. D. Maxson (M '44), Vice-President, Public Service Company of Northern Illinois, Chicago, Ill., has been elected Vice-President of the Commonwealth Edison Company. In a new organization alignment affecting system engineering Mr. Maxson will be in charge of corresponding work in both companies. Mr. Maxson joined the Public Service Company in 1921 and progressed to the rank of division manager in 1936 and to Vice-President in 1943. He is a member of the Western Society of Engineers. Mr. Maxson is currently serving the AIEE on the Code of Principles of Professional Conduct Committee.

H. L. Hazen (AM '26, F '43), professor and Head of the Electrical Engineering Department, Massachusetts Institute of Technology (MIT), Cambridge, Mass., has been made Dean of the Institute's Graduate School effective as of July 1952. Dr. Hazen was born in Philo, Ill., on August 1, 1901, and received his bachelor of science (1924), master of science (1929), and doctor of science (1931) degrees from the Massachusetts Institute of Technology. He was made assistant professor of electrical engineering at MIT in 1931, associate professor in 1934, and professor and Head of the Department of Electrical Engineering in 1938. Dr. Hazen is the author of many technical articles in the field of electrical engineering. He is a member of the American Academy of Arts and Sciences, the Franklin Institute, Sigma Xi, and Tau Beta Pi.

Ralph Bown (M '30, F '41), Director of Research, Bell Telephone Laboratories, Inc., Murray Hill, N. J., has been appointed Vice-President in charge of research. **H. T. Friis** (AM '20, F '41), radio research director, Bell Telephone Laboratories, Inc., Red Bank, N. J., has been appointed Director of Research in high frequency and electronics. Dr. Bown, who is well known for his pioneering research and development work in the field of communications engineering, has been with the company since 1934. Dr. Friis, who joined the Western Electric Company in 1919, has been associated with the Laboratories since 1930, in charge of short-wave research studies and transmission studies of waves in the centimeter range.

C. L. Derrick (AM '40, M '50), Assistant Vice-President, Hartford Electric Light Company, Hartford, Conn., has been elected Vice-President of the company. Mr. Derrick joined the company in 1942 as assistant engineer, later became superintendent of engineering, and was promoted to Assistant Vice-President in 1951. His previous experience included association for 19 years with the Public Service Electric and Gas Company of New Jersey.

T. G. LeClair (AM '24, F '40), chief electrical engineer, Commonwealth Edison Company, Chicago, Ill., has been appointed manager of engineering. Mr. LeClair, Past President of the AIEE (1950–51), joined the Edison Company in 1923, and has been chief electrical engineer for the past two years.

W. A. Thomas (AM '32, M '43), associate professor of electrical engineering, Case Institute of Technology, Cleveland, Ohio, has joined the engineering staff of The Electric Products Company, Cleveland, Ohio. Dr. Thomas had been on the faculty of Case Institute since 1948, and previous to that time he had been associated with E. I. DuPont de Nemours, Inc., Wilmington, Del. He is currently serving on the AIEE Basic Sciences Committee.

W. E. Brainard (AM '33), Vice-President, Arcrods Corporation, Sparrows Point, Md., has been elected President and Director of the company. Mr. Brainard joined Arcrods in 1939 as superintendent of the Cleveland, Ohio, plant, and five years later became Director of Production. He was appointed Assistant to the Vice-President in 1946 and elected Vice-President in 1948. Mr. Brainard is a member of the American Welding Society.

M. B. Elliott (M '45), manager, unit equipment division, Apparatus Department, General Electric Company, Schenectady, N. Y., has been granted a leave of absence to serve in an advisory capacity with the National Production Authority, Washington, D. C. Mr. Elliott was graduated in 1920 from Virginia Polytechnic Institute with a bachelor of science degree in electrical engineering and became associated with General Electric that same year. Mr. Elliott was appointed manager of the company's unit equipment division in 1945.

A. J. Hoehn (A '42, M '51), electrical engineering division, and **C. C. Petersen** (A '50), associate electrical engineer, both of the Armour Research Foundation, Chicago, Ill., have been made supervisors of the communications and materials and measurements sections respectively. Mr. Hoehn is a member of the Institute of Radio Engineers and Sigma Xi. He has been associated with the Foundation since 1947. Mr. Petersen joined the staff of the Foundation in 1946. He is a member of the American Society for Testing Materials and the Institute of Radio Engineers.

E. F. Seaman (M '43), electrical engineer, Bureau of Ships, United States Navy Department, Washington, D. C., was presented with the Distinguished Civilian Service Award. The award was made to Mr. Seaman for his outstanding work with the Bureau's program for conservation of critical materials. He served on the Institute Research Committee (1949–51).

C. C. Herskind (A '26, F '48), electrical engineer, and **W. R. Kettenring** (A '47), electrical engineer, both of the General Electric Company, Schenectady, N. Y., have been appointed to the positions of section engineer to direct development of power electronic equipment and components, and section engineer to direct product design of power electronic equipment, respectively.

M. S. McIlroy (M '36), professor of electrical engineering, Cornell University, Ithaca, N. Y., has been appointed assistant director of the School of Electrical Engineering at Cornell. He has been a member of the faculty of the university since 1947. He is currently serving the Institute on the Computing Devices Committee.

A. W. Friend (A '33, M '39), research engineer, RCA Laboratories, Radio Corporation of America, Princeton, N. J., has been appointed Director of Engineering and Development, Magnetic Metals Company, Camden, N. J. He had been associated with the RCA Laboratories since 1944 where he was engaged in research in the television field and other branches of communications. He served on the AIEE Education Committee (1949–52).

J. H. Pharis, Jr. (A '47), sales engineer, Apparatus Department, General Electric Company, Roanoke, Va., has been made manager of the Roanoke office. Mr. Pharis is a graduate of Virginia Polytechnic Institute. He joined General Electric in 1933, and following a series of assignments in service engineering and application engineering, he joined the sales force of the Roanoke office in 1945.

E. W. Loomis (A '19, M '45), Vice-President, Westinghouse Electric Corporation, Philadelphia, Pa., was re-elected President of the Electrical Association of Philadelphia for 1952. **J. B. Harris, Jr.** (A '17, M '45), President, Rumsey Electric Company, Philadelphia, Pa., has been elected Vice-President of the Electrical Association of Philadelphia for 1952.

G. W. Thaxton (M '36, F '43), regional engineer, Power Supply Division, Defense Electric Power Administration, Washington, D. C., has been appointed power engineer, Construction and Supply Division, United States Atomic Energy Commission, Washington, D. C.

E. R. Narum (A '48), application engineer, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been assigned to the Detroit, Mich., district office of the company's general machinery division. Mr. Narum has been associated with the company for four years.

J. C. Amos (A '49), substation design engineer, Public Service Company of Oklahoma, Tulsa, Okla., has been appointed development engineer for the Gaseous Diffusion Plant, operated by Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation, Oak Ridge, Tenn.

T. A. Abbott (A '26, F '50), executive director, Engineering Research Department, Standard Oil Company of Indiana, Chicago, Ill., has been appointed manager of the Engineering Research Department. Mr.

Abbott joined the company in 1946. He previously had served with Republic Flow Meters Company, Armour Research Corporation, Kellex Corporation, and General Electric Company.

C. R. Martin (A '44), assistant chief inspector, general machinery division, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been placed in charge of manufacturing, production planning, and production control. He has been associated with the company since 1937 and is a member of the American Society for Quality Control.

C. W. Kuhn (A '23, F '39), assistant manager, Development Department, Cutler-Hammer, Inc., Milwaukee, Wis., has been appointed Director of Development Engineering. In 1925 he became a member of the firm's Development Department and since 1946 has been its assistant manager.

R. A. Millermaster (M '34, F '49), assistant manager, Development Department, Cutler-Hammer, Inc., Milwaukee, Wis., has been appointed manager of the Development Department. Mr. Millermaster became associated with the company in 1927. He has served the Institute on the Air Transportation Committee (1945–52).

H. H. Hanft (M '48), manager, land transportation sales section, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been named assistant to the manager of the Industrial Department of the company.

G. W. Ledbetter (A '43, M '48), district engineer, Luminator, Inc., Van Nuys, Calif., has been appointed West Coast representative for the Electro-Snap Division, Exhibit Supply Company, Chicago, Ill.

OBITUARY

Clyde Higbee Loughridge (M '26, F '45), consulting electrical engineer, Cleveland, Ohio, died on December 28, 1951. He was born on June 16, 1882, in Pittsburgh, Pa., and was graduated from Cornell University in 1904. Before entering private practise as a consulting engineer, Mr. Loughridge had been associated with various companies, among them the Bureau of Filtration, Pittsburgh, Pa.; H. Koppers Coal and Coke Company; The Martien Electric Company; and he had been associated with several consulting firms. Mr. Loughridge was responsible for the electrical plans of many of the principal buildings in the Cleveland area including the Cleveland Public Library, the McKinney Steel Company office building, the Allen Memorial Library, and many others. He was a member of the National Society of Professional Engineers.

Cyrus Day Backus (AM '07, M '26, Member for Life), patent attorney, Washington, D. C., died on August 3, 1951. He was born on February 13, 1875, in Groton, N. Y., received his bachelor of laws degree from Cornell University in 1896, and his master of science degree in electrical engineering from George Washington University a few years later. He entered the United States Patent Office as assistant examiner in 1903 and rose to the position of primary examiner in the radio division and was an authority in the communications field. Following his retirement from the Patent Office in 1943, he was for four years a patent law consultant to the International Telephone and Telegraph Company, New York, N. Y., and then returned to private practise in Washington, D. C. He was a member of the Institute of Radio Engineers and the American Association for the Advancement of Science.

Edward Nathan Strait (AM '11, Member for Life), public utility consultant, Oak Park, Ill., died on December 23, 1951. He was born on April 29, 1885, in Sparta, Wis., and was graduated from the University of Wisconsin in 1902 with a bachelor of science degree and in 1906 with an electrical engineering degree. He was associated with the Wisconsin Railroad Commission as rate and valuation engineer from 1907 to 1916 and then for 34 years was manager of the Rate Research Department of Pioneer Service and Engineering Company, retiring in 1950. He was a member of the Illuminating Engineering Society and the Western Society of Engineers.

Arthur M. Frost (AM '49), director of plant engineering, Douglas Aircraft Company, Santa Monica, Calif., died on November 6, 1951. He was born in Pasadena, Calif., on July 19, 1915, and was graduated with a bachelor of science degree in electrical engineering from the California Institute of Technology in 1936. That same year he became associated with the Douglas Aircraft Company as an electrical engineer, and in 1941 was made assistant director of plant engineering. In 1950 he was appointed director of plant engineering. Mr. Frost was a member of Tau Beta Pi and the Illuminating Engineering Society.

Louis Tucker Peck (AM '11, M '22, Member for Life), Vice-President, Moloney Electric Company, Alexandria, Va., died on January 7, 1952. He was born in Stanton, Va., in 1877, and spent three years in the electrical engineering course at Ohio State University. He was associated with the Southern Power Company, Charlotte, N. C., in the capacity of sales engineer from 1909–10. In 1910 he joined the Westinghouse Electric Corporation as sales engineer and later became manager director of their expansion program in South America, China, and India. After his return to this country he joined the Moloney Electric Company and has been in charge of the Alexandria office since 1928.

Jesse Eugene Mateer (AM '04, Member for Life), retired, East Pittsburgh, Pa., died on November 10, 1951. He was born on September 25, 1875, in Milford Pa. He was graduated from Franklin and Marshall College in 1897 with a bachelor of arts degree. He later studied electrical engineering at Pennsylvania State College. He began his career at the Westinghouse Electric Corporation in 1901 and was associated with that company until his retirement.

E. S. Kessler (AM '29), division manager, Pacific Electric Manufacturing Corporation, Gary, Ind., died on August 26, 1951. He was born in May 1900 in San Francisco, Calif., and was a graduate of the California School of Mechanical Arts. He had been associated with the Pacific Electric Manufacturing Corporation since 1925.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of January 17, 1952, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Fellow

Hubbard, D. C., chief development engr., A. B. Chance Co., Centralia, Mo.

1 to grade of Fellow

To Grade of Member

Allen, E. J., elec. engr., Weston Electrical Instrument Corp., Newark, N. J.
Boesewetter, C. C., mgr., testing dept., Goodman Mfg. Co., Chicago, Ill.
Buckles, R. A., Jr., member, patent staff, Bell Telephone Laboratories, Inc., New York, N. Y.
Caldwell, R. J., engr., General Radio Co., Cambridge, Mass.
Dingler, J. B., engr., Southern California Edison Co., Los Angeles, Calif.
Dryer, H. V., product section engr., Line Material Co., South Milwaukee, Wis.
Fitzsimmons, D. P., projects engr., Union Switch & Signal Div., Westinghouse Airbrake Co., Pittsburgh, Pa.
Grant, R. M., elec. engr., Peter F. Loftus Corp., Pittsburgh, Pa.
Harmon, R. C., owner & chief engr., Harmon Electronics Co., Independence, Mo.
Harris, B. M., planner, power transformer engg., General Electric Co., Pittsfield, Mass.
Kenyon, J. S., electrolysis engr., Public Service Co. of Colorado, Denver, Colo.
Lang, J. T., asst. supt., meter dept., Public Service Co. of Colorado, Denver, Colo.
Langell, S. A., meter engr., The Ohio Power Co., Canton, Ohio
MacPherson, C. A., design engr., Canadian Controllers, Ltd., Toronto, Ont., Can.
Oestreicher, S., chief engr., welder & motor div., Harnishfeger Corp., Milwaukee, Wis.
Post, J. H., elec. designer, General Electric Co., Richland, Wash.
Ridgley, C. H., plant mgr., General Electric Co., Johnson City, N. Y.
Sandusky, R. C., elec. engg. associate, Department of Water & Power, Los Angeles, Calif.
Shorey, Laurence Forrest, asst. prof. of elec. engg., University of Vermont, Burlington, Vt.
Stephens, W. J., elec. engr., Public Service Co. of Colorado, Denver, Colo.
Walsh, L., owner, Walsh Engineering Co., Elizabeth, N. J.
Webb, W. L., director of engineering & research, Bendix Radio, Towson, Md.
Yeakle, R. B., project engr., General Cable Corp., Perth Amboy, N. J.

23 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before March 25, 1952, or May 25, 1952, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Forster, A. M., Aluminum Co. of Canada Ltd., Montreal, Que., Can.
Klemperer, H. (re-election), Air Preheater Co., New York, N. Y.
Scott, L. R. (re-election), Rochester Gas & Elec. Corp., Rochester, N. Y.

3 to grade of Member

OF CURRENT INTEREST

Chile Harnesses Water Power from Andes Mountains in Industrialization Program

Water power from the Andes Mountains, one of the greatest potentials in the world, is being turned into electricity by the government of Chile to develop new industries. The 23,000-foot-high snow-capped peaks provide water pressure that is converting Chile into a modern industrialized nation. Working at 10,000-foot altitudes an investment of $75,000,000 and 4½ per cent of the country's hydroelectric potential.

It is estimated that in 1953 Chile will produce 4,000,000 kilowatt-hours of electricity and 2,000,000 kilowatt-hours will be used by industry.

Completed plants are located at Abanico

The penstocks of the Abanico, Chile, power plant line up directly with the bank of transformers in the background

on narrow edges causes much of the mountainous tunneling and channeling to be done by manual labor.

Three hydroelectric plants already completed have a capacity of 218,000 kw and three more with a total of 197,000 kw are under construction. These plants represent (shown on the cover) with an output of 120,000 kw, Sauzal, and Pilmaiquen.

Power from the Sauzal plant which is located south of Santiago, the capital of the country, eventually will electrify the southern section of the state railways and pumps to irrigate 225,000 acres of fertile land.

Electronic Elevator Supervisor in New Building Fills Heavy Traffic Demands

Elevators so controlled electronically that greater service is available to meet heavy traffic demands have been installed in the new 32-story, air-conditioned Chrysler Building East, New York City, N. Y., which was opened in November 1951.

Installed by the Otis Elevator Company, the 18 elevators in the new building are controlled by the Autotronic System. This system permits the supervisor of the elevator service, by a simple turn of a knob, to select whichever of six basic traffic programs meets the requirements of a particular traffic pattern.

As workers surge into the building in the morning, cars will be operated on an up-peak program that sends cars from the lobby as rapidly as they are filled. During mid-morning and midafternoon hours, a balanced up-down program is in force. As the mid-day lunch period approaches, the supervisor switches to a heavier down program, spacing the down cars to compensate for the greater number and duration of their stops.

Toward the end of the lunch period, when the traffic again is predominantly upwards, the heavier up program is put into effect. At the close of the business day the down-peak program again is put into operation, thus rapidly emptying the building.

Finally, at the end of the day a night program allows effective 1-car operation for intermittent traffic at night, on Sundays, and holidays.

Two further variations are permitted. An optional zone return system is provided for the bank of cars servicing the upper 19 floors of the new building. Under this system, half the cars may be dispatched automatically to handle the lower ten floors in the zone while the remaining cars serve passengers from the top nine. This would be applicable at closing hours, with the heavy rush of down traffic.

Also, should fully laden cars repeatedly pass a waiting passenger on any floor, his call will be detected electronically and a car will be dispatched automatically from the lobby to pick him up.

Use of the new electronic touch buttons is another interesting feature of the elevators in the Chrysler Building East. These buttons, recessed in a plastic panel, require no pressure, but are activated merely by the touch of an extended finger. With that touch, the call is registered in the proper electronic circuit and the up or down button remains glowing until the arrival of the car.

The face of the button is covered with an insulating material with a high dielectric constant. The back of the button consists of an electrically conductive material and makes contact through a spring with an electrically conductive coating on the top of an electron tube. Thus, the button forms one plate and the dielectric of a capacitor. The electron tube is a cold-cathode gas-filled tube, the principal components of this tube being the anode, cathode, and neon. It also has a very thin

Future Meetings of Other Societies

American Power Conference. 1st Annual Conference. March 26–28, 1952, Sherman Hotel, Chicago, Ill.

American Society for Testing Materials. Spring Meeting. March 3–7, 1952, Hotel Statler, Cleveland, Ohio.

American Society of Tool Engineers. 20th Annual Meeting. March 17–21, 1952, Conrad Hilton Hotel, Chicago, Ill.

Institute of Radio Engineers. Annual Convention, March 3–6, 1952, Waldorf-Astoria Hotel and Grand Central Palace, New York, N. Y.

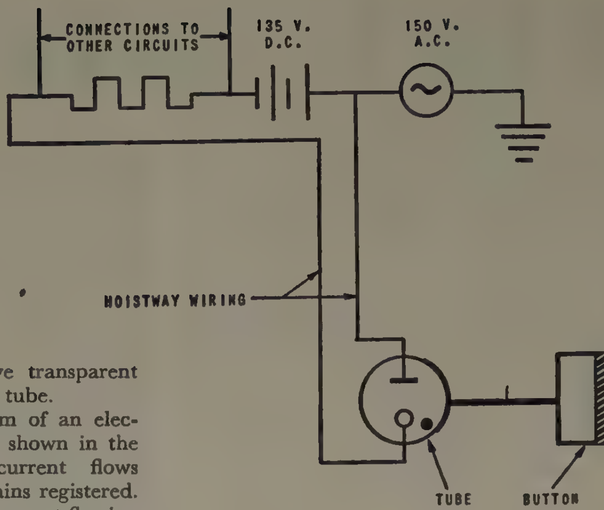
National Association of Corrosion Engineers. Annual Conference. March 10–14, 1952, Buccaneer Hotel, Galveston, Tex.

National Electrical Manufacturers Association. March 10–13, 1952, Edgewater Beach Hotel, Chicago, Ill.

Pennsylvania Electric Association. Spring Meeting, Meter Committee. April 17–18, 1952. Hotel Yorktowne, York, Pa.

The American Society of Mechanical Engineers. Spring Meeting. March 24–26, 1952, University of Washington, Seattle, Wash.

The Society of the Plastics Industry, Inc. Fifth National Plastics Exposition. March 11–14, 1952, Convention Hall, Philadelphia, Pa.



Schematic diagram of the electronic push button for elevator signaling, an interesting feature of the elevators in the new Chrysler Building East

film of electrically conductive transparent material on the outside of the tube.

A simplified wiring diagram of an electronic touch button circuit is shown in the illustration. As long as current flows through the tube, a call remains registered. Conversely, when there is no current flowing through the tube there is no call registered.

Assume that there is no call registered, and no current is flowing through the tube. There is 135-volt d-c potential across the gap between the anode and cathode of the tube but this potential is not great enough to start a flow of current. There is also a 150-volt a-c potential between the anode and ground. When a prospective passenger places his finger on the button, the distribution of the electrostatic fields inside the tube is changed sufficiently for the tube to ignite and start conducting current. Current continues to flow through the tube after the prospective passenger takes his finger off the button because the 135-volt potential is sufficient to maintain a flow of current once it is started. The flow of current through the tube not only registers the call, but also causes the tube to light up with a color characteristic of the contained gas. The light from the tube illuminates the translucent arrow in the fixture's face plate, indicating to the prospective passenger that his call is registered.

When an elevator answers the call, a pulse of voltage is applied to the circuit which momentarily reduces the potential across the tube to a value that will not maintain a flow of current. The tube then stops conducting and the registered call is cancelled.

Ten-Channel In-Flight Calibrator Identifies Telemetered Information

A 10-channel in-flight calibrator recently developed by the National Bureau of Standards (NBS) utilizes a unique system of cam-operated switches that eliminates many of the difficulties encountered in calibrators of comparable size and scope. Designed to identify telemetered information from a guided missile in flight, the device is compact and durable and particularly suited to telemetering applications in aircraft, missiles, or projectiles.

Telemetering involves the measurement of one or more quantities by electric instruments, the transmission of the data to a distant receiving station, and the receipt and recording of the measured quantities. The information usually is transmitted by radio, although under some circumstances it may be carried by wire. The transmitted signals may be derived from transducers or pickups which translate mechanical movement into electric impulses or they may be derived through direct coupling to electric circuits. Normally, the information then is used to modulate a high-frequency radio carrier.

At the receiver-recorder it is virtually impossible to assign any finite value to the received information until two or more reference levels of modulation have been established in terms of the response of the receiving equipment. The NBS in-flight calibrator sequentially supplies each intelligence channel with four known levels of modulation. Thus, the telemetering record is provided with known reference levels of modulation from which the received data may be interpreted.

Transmission control of the calibrating signal, as well as the data signal, is achieved through the action of two groups of noise-free switches involving 40 separate switching operations. The first group contains ten single-pole double-throw switches operated in sequence by a motor-driven cam. Its function is to interrupt briefly and periodically the normal channeling of the operating information to the radio-frequency transmitter and to connect the calibrating circuit to the output instead.

The second switching group contains four single-pole single-throw switches, also operated by a motor-driven cam. The function of this group is to pass step-calibrating signals sequentially to the transmitter during the interval in which a particular telemetering channel is interrupted by the first group of switches. The step-calibrating cam cycles ten times (four modulating signals with each cycle) for each cycle of the channel-interrupting cam; each interrupted channel receives identical calibrating signals.

All switches and cams are in a cylinder about 2 inches long and 4 inches in diameter. The drive motor for both cams is mounted at one end of the calibrator.

The NBS in-flight calibrator could be expanded easily to permit operation of 20 telemetering channels. This simply would involve installing ten more switches, increasing the width of the slow-speed cam, and enlarging the calibrator housing to accommodate the additional switches. Such an arrangement would permit two channels to be calibrated simultaneously; each channel would be recalibrated every ten calibration cycles.

The four reference calibration levels supplied by the NBS calibrator to the transmitter usually are chosen so as to divide the total modulation range into equal parts on the record. Thus, the traces of the calibration signals not only form a basis for assigning calibration values to the record but also provide a means for correcting for any nonlinear qualities of the transmitter and receiver-recorder.

Seagoing Broadcast Station Added to Voice of America

The most powerful radio transmitting equipment ever installed on a ship is being built into an ex-Navy cargo vessel now being converted into the Voice of America's first seagoing broadcasting station, it was revealed recently by the Office of International Broadcasting of the United States State Department.

The first phase of a project known as "Operation Vagabond," the conversion of the World War II vessel is expected to increase effectiveness in beaming broadcasts behind the Iron Curtain and to minimize interference by Soviet jammers.

In operation the floating relay station would pick up the Voice of America signals as they are transmitted from the United States and beam them directly into the target countries, reaching many areas now blacked out. The ability of the station to shift operations continually provides the Voice of America with a means of dodging stationary Soviet jamming facilities.

Although the exact range of the relay station was not revealed, a special 100-foot flight deck is being built on the ship for barrage balloons which will carry antennas aloft to increase the range of the station.

A special air-conditioning system for the transmitting room was developed by Minneapolis-Honeywell Regulator Company marine engineers in collaboration with naval architects to enable the relay station to broadcast under all weather conditions. Engineers explained that the transmitting equipment, several times more powerful than that of standard land-based stations, generates immense heat. This heat would make the radio room unbearable, particularly during heavy weather when normal ventilation openings would be shut.

Illinois Institute of Technology Offers Research Fellowships

Armour Research Foundation of Illinois Institute of Technology is offering industrial research fellowships in physics, chemistry, metallurgy, ceramics, engineering mechanics, and electrical engineering to begin in September 1952.

Those persons awarded fellowships will attend Illinois Institute of Technology half-time and work in the Research Foundation half-time in a graduate program leading to advanced academic degrees. They are employed full-time by the Foundation during the summer.

The Foundation awarded seven fellowships in 1951 and plans to award about 15 this year. Fellowships begin at the start of the school semester and continue through the summer for approximately 21 months until the end of the second academic year.

Awards are made on a competitive basis to United States citizens under 28 years of age holding a bachelor's degree from an accredited engineering or scientific school or liberal arts college with a major in the sciences.

In addition to tuition, fellows receive $165 a month during the first academic year, $325 a month and a 2-week vacation during the summer, and $190 a month during the second academic year. Successful candidates are encouraged to accept full-time summer employment preceding the Fellowship at a rate of $300 a month.

Application forms may be obtained from the Office of Admissions, Graduate School of Illinois Institute of Technology, Chicago, Ill. Applications received prior to March 15 will be given first consideration.

Simplified Radioactivity Survey Instrument Developed by NBS

Portable self-contained radioactivity survey instruments of the gamma type generally use a microammeter to indicate the radiation level. Ideally these survey instruments should be low in cost as well as compact and rugged. Yet microammeters are inherently neither cheap nor rugged, nor are they suited to mass production in extremely large volume. A new gamma survey instrument, recently developed by the National Bureau of Standards (NBS) electronic instrumentation laboratory, requires no microammeter.

In the NBS instrument, which was developed for the United States Navy Bureau of Ships, radiation levels are read directly from a potentiometer dial. To read an unknown value of radiation, the operator turns the dial to the point at which an audio-oscillation just begins. This point is determined aurally with the small earphone that is standard equipment for most survey instruments. This aural indication is particularly convenient for plotting contours of equal radioactivity; with the dial set for a particular radiation level, it is an easy matter for the operator to walk along and locate aurally a series of equally radioactive points.

Like many other gamma-radiation survey instruments, the NBS device uses a detector tube of the halogen-filled Geiger-Mueller type, together with a vibrator high-voltage power supply operating from flashlight-type batteries. Output current of the detector is proportional to the incident radiation.

The heart of the aural indication method is a thyratron relaxation oscillator circuit. If the potential difference between the grid and cathode of the thyratron exceeds the firing potential, the circuit will oscillate. The unknown voltage derived from the detector tube current is applied to the outer terminals of the potentiometer, while the thyratron grid is connected to the moving contact. The potentiometer setting at the threshold of oscillation thus depends on the radiation level, and the potentiometer dial can be calibrated directly in radiation units.

60-Mile Microwave Relay System Set up for Experimentation

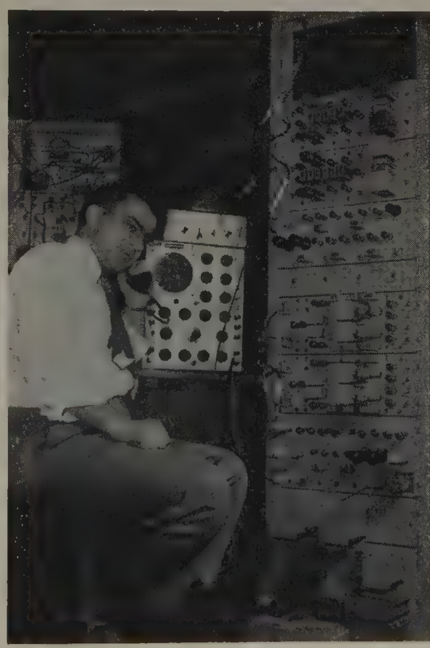
A 60-mile multichannel microwave relay radio communications system has been built for experimentation at Electronics Park, Syracuse, N. Y., by the General Electric Company. Its purpose is to help develop and test new and improved communications equipment for civilian and military uses.

Engineers literally talk to themselves while operating the system. In their laboratory, they talk into a telephone handset. Their voices are relayed four times over the 60-mile course, and heard from a loudspeaker in the laboratory with no noticeable time lag.

Signals are beamed from an antenna atop the laboratory at Electronics Park to a relay station 15 miles to the south. This station, unattended, relays them to another relay station on a hill 15 miles further south. Here they are placed automatically on another channel and beamed back to Electronics Park over the same route.

A second system now is being constructed between Electronics Park and a point near Utica, N. Y., providing a round-trip circuit of 80 miles.

Relay station atop a 2,000-foot hill near DeRuyter, N. Y., receives microwave radio signals from Electronics Park via a similar station near Pompey, N. Y. At the DeRuyter station the signals are automatically put on another channel and sent back to the Park. The round-trip setup eliminates the need for operators in the field who normally would be used to check reception at the two relay points. One antenna and reflector are shown on the roof of the tower



This engineer talks to himself via a 30-mile microwave radio relay system which the General Electric Company is operating experimentally between Electronics Park at Syracuse and DeRuyter, N. Y. Signals are beamed to a relay station near Pompey, N. Y., which passes them to the DeRuyter station. There they are placed automatically on another channel, sent back to the Park via the Pompey station, and fed into a loudspeaker in the laboratory. The 60-mile round trip takes about 0.0003 second

Sending and receiving antennas must be within sight of each other, with their separating distances governed by the terrain between them. The signals can be relayed any number of times to cover longer distances.

As many as 24 separate conversations can be handled simultaneously by microwave systems. If desired, some of these channels can be used to carry signals which can control such things as electric power stations, pipe line valves, and so forth.

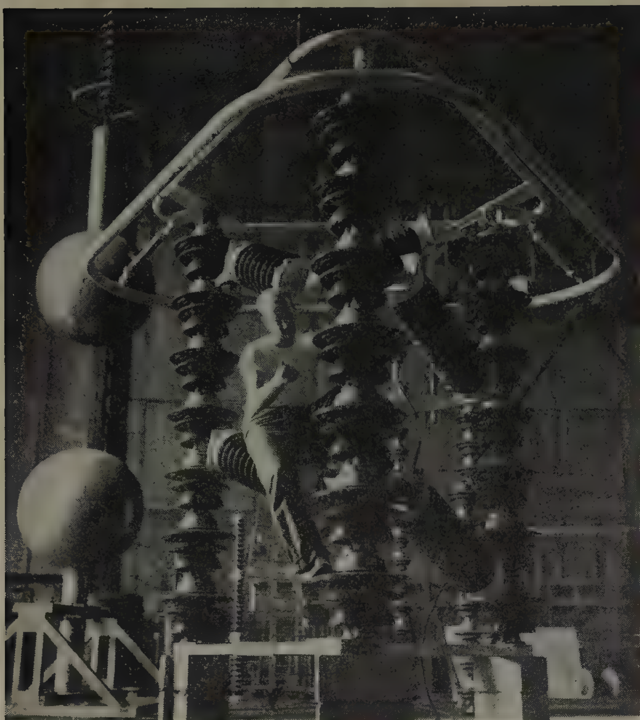
The military services use microwave systems for private communication between battle fronts and rear areas. These systems are less prey to ice storms, landslides, stray bullets, and enemy action than land lines which always have been difficult to maintain across wild, hilly terrain.

High-School Science Teachers Eligible for Summer Fellowships

Between 20 and 40 fellowships, each valued at $250, will be awarded to secondary-school science teachers who will participate in a special six weeks' summer program at Carnegie Institute of Technology, Pittsburgh, Pa. The 1952 fellowships have been made available by the Westinghouse Educational Foundation which is maintained by the Westinghouse Electric Corporation. This marks the second annual program for the secondary-school teachers of science.

The program of study stresses the importance of fundamental concepts in chemistry, physics, and mathematics, and provides a survey of recent developments in the pure and applied sciences. The academic pro-

Self-Supporting Lightning Arrester



This 195-kv self-supporting lightning arrester being readied for tests at the Westinghouse Electric Corporation's high-voltage laboratory at Trafford, Pa., utilizes a spiral arrangement of the lightning-arrester units that eliminates the need for structural supports. Only 10 feet tall, the new design reduces both space requirements and cost. The lightning-arrester assembly can be mounted on wheels for greater utility. The 195-kv assembly is used in connection with 230-kv lines

gram consists of lectures on such topics as radioactivity, nuclear research, synthetic rubber, petroleum, and applied mathematics.

This program is supplemented by visits to Carnegie Institute of Technology's research and teaching laboratories, and to some of the industrial establishments of the Pittsburgh area.

Eighteen units (six hours) of college credit will be granted for the academic work of this 6-week program. Full-time staff members of the College of Engineering and Science of the Institute will have charge of the course.

As Mr. A. C. Monteith, Vice-President of the Westinghouse Electric Corporation and chairman of the Westinghouse Educational Foundation, observed in the announcement of last year's fellowship, "In this age of technical achievement, the role of the secondary-school science teacher is becoming increasingly important. If industry is to maintain a steady flow of competent engineers and scientists, then it must give all possible support and encouragement to the teachers in secondary schools. They are generally the first persons to recognize the hidden talents and capabilities of the science student and send him on his way to a satisfying career."

The program which begins June 30 will extend through Friday, August 8, and no Saturday sessions will be held. A tuition fee of $50 will be charged for the 6-week course and the balance of the $250 fellowships can be applied to commuting or living expenses. Living accommodations in Carnegie dormitories will be available at reasonable rates and dining facilities are available on the campus.

Application forms and further information about the summer program can be obtained from the Director of Admissions, Carnegie Institute of Technology, Pittsburgh 13, Pa.

Engineers Needed to Aid in High-School Guidance Program

In a report that points up the immediate necessity for all engineers to join in guidance work as an aid to hard-pressed high-school teachers, the Engineers' Council for Professional Development has formulated a program to meet this emergency.

The plan includes dividing the United States and Canada into regions headed by chairmen. These men will be available through the national organization which has descriptive folders of engineering careers as well as self-appraisal questionnaires which will permit students to determine their qualifications for engineering careers. The regional program will have the effect of increasing the number of committees at work on student guidance in the cities of the nation. These committees, consisting of volunteer practising engineers, will form groups which will visit high schools giving talks on engineering to senior students.

Request for information or guidance pamphlets should be addressed to Engineers' Council for Professional Development, 29 West 39th Street, New York 18, N. Y.

British Contribution to TV Subject of IEE Convention

The Committee of the Radio Section, acting on behalf of the Council of The Institution of Electrical Engineers (IEE), will hold a convention known as "The British Contribution to Television," in London, England, April 28–May 3, 1952. Overseas visitors are welcome.

The convention will be organized into nine sessions covering the complete field of television. Each session will include the presentation and discussion of technical papers and will be supplemented by demonstrations where applicable. Inspection trips to organizations concerned with every aspect of television will be included in the week's program.

Full information and application forms for registration can be obtained from the Secretary of The Institution of Electrical Engineers, Savoy Place, London, W. C. 2, England.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Franklin's Kite Adventure

To the Editor:

It was with great interest that I read the article, "Benjamin Franklin's Kite Experiment and Other Electrical Discoveries," by Janet Bermingham that appeared in the January 1952 issue of *Electrical Engineering*. However, I note with regret that Mrs. Bermingham, like others who have written about B. Franklin's kite adventure, has misquoted slightly the details which add so much to the importance of this historic experiment. Mrs. Bermingham quotes Howard McClenahan as follows, "When the silk cord by which it was held became wet from rain, he could, and did, draw electric sparks from the brass key which was tied to the lower end of the cord." Compare these words with Franklin's own in a letter dated October 19, 1752, which was published on page 111 of a book entitled "Experiments and Observations on Electricity, Made at Philadelphia in America," by Benj. Franklin, L.L.D. and F.R.S.

"As frequent mention is made in public papers from Europe of the success of the Philadelphia experiment for drawing the electric fire from clouds by means of pointed rods of iron erected on high buildings, etc.,

it may be agreeable to the curious to be informed that the same experiment has succeeded in Philadelphia, though made in a different and more easy manner, which is as follows:

"Make a small cross of two light strips of cedar, the arms so long as to reach to the four corners of a large, thin silk handkerchief when extended; tie the corners of the handkerchief to the extremities of the cross so you have the body of a kite; which being properly accomodated with a tail, loop and string, will rise in the air, like those made of paper; but this being of silk, is fitter to bear the wet and wind of a thunder-gust without tearing. To the top of the upright stick of the cross is to be fixed a very sharp pointed wire, rising a foot or more above the wood. To the end of the twine, next the hand, is to be tied a silk ribbon, and where the silk and twine join, a key may be fastened. This kite is to be raised when a thunder-gust appears to be coming on, and the person who holds the string must stand within a door or window, or under some cover, so that the silk ribbon may not be wet; and care must be taken that the twine does not touch the frame of the door or window. As soon as any of the thunder clouds come over the kite, the pointed wire will draw the electric fire from them, and the kite, with all the twine, will be electrified, and the loose filaments of the twine will stand out in every way, and be attracted by the approaching finger. And when the rain has wet the kite and twine, so that it can conduct the electric fire freely, you will find it stream out plentifully from the key on the approach of your knuckle."

Note especially the statements, "so that the silk ribbon may not be wet," and "the rain has wet the kite and twine." Franklin, being fully aware of the potent ability of this natural source of electricity, took the necessary precautions. Though he did not use the terms specifically, he could distinguish between a conductor (wet twine) and an insulator (dry silk), and the fact that he recognized the distinguishing characteristics contributed much to the fact that he lived a good 40 years after the date of his memorable experiment. It is also interesting to note that though many an artist has pictured the incident otherwise, Franklin had "sense enough to come in out of the rain" when performing the kite experiment.

JOSEPH C. MICHALOWICZ (M '47)

(The Catholic University of America, Washington, D. C.)

Correction in Equations

To the Editor:

I submit the following errata in my article, "Analysis of the Drag-Cup A-C Tachometer," page 66 of the January 1952 issue of *Electrical Engineering*.

In equation 2, ϵ should be replaced by α.

In equations 6 and 7, the last exponents 2 should be deleted, so that the equations will read

$$A_2 = a^2 b x_{11} - a \tag{6}$$

$$B_3 = a^2 b r_{1m} \tag{7}$$

R. H. FRAZIER (F'50)

(Massachusetts Institute of Technology, Cambridge 39, Mass.)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ADVANCED ENGINEERING MATHEMATICS. By C. R. Wylie, Jr. McGraw-Hill Book Company, New York, N. Y., 1951. 640 pages, charts, diagrams, tables, 9 1/2 by 6 1/2 inches, cloth, $7.50. This comprehensive work covers ordinary and partial differential equations, Fourier series and the Fourier integral, operational calculus developed through the use of the Laplace transform, Bessel functions, theory of functions of a complex variable, vector analysis, and such techniques of advanced numerical computation as the numerical solution of equations and systems of equations, finite differences, harmonic analysis, least squares, and the method of Stodola. Applications are illustrated in the fields of mechanical and electrical circuits, vibration, fluid flow, and so forth.

ADVANCED THEORY OF WAVEGUIDES. By L. Lewin. Published for "Wireless Engineer" by Iliffe and Sons, Ltd., London, England, 1951. 192 pages, charts, diagrams, 8 3/4 by 5 3/4 inches, cloth, 30s. In dealing with various methods that have been found successful in treating waveguide problems, the author has selected for discussion a number of topics as representative of the field in which the microwave engineer is at present engaged: cylindrical posts in waveguides; diaphragms; the tuned post and the tuned window; waveguide steps, T-junctions, and tapers; radiation from waveguides; propagation in loaded and corrugated guides. Familiarity with waveguide theory and the necessary advanced mathematics is assumed.

ALTERNATING CURRENT CIRCUITS. By K. Y. Tang. International Textbook Company, Scranton 9, Pa. Second edition, 1951. 603 pages, charts, diagrams, tables, 9 1/4 by 6 1/4 inches, cloth, $6.00. Intended as an introductory course in the study of circuit analysis, the material here presented should precede the study of a-c machinery, power, and communication networks. The physical nature of circuit elements and the principles and laws of electric circuits are covered, with emphasis on the effects of the circuit elements on the flow of current and the relations of instantaneous values. A chapter on impedance transformation has been added, and considerable revision has been done to provide a more logical treatment.

BOILER FEED WATER TREATMENT. By F. J. Matthews. Chemical Publishing Company, Inc., 212 Fifth Avenue, New York, N. Y. Third edition, 1951. 207 pages, charts, diagrams, illustrations, 8 3/4 by 5 1/2 inches, cloth, $4.50. This work is divided into sections dealing with the principal operating problems: scale formation, corrosion, foaming and priming, analysis, and routine testing. The object is to present in collected form information of value to the small "ordinary" plant operator who must handle his own problems.

CORROSION. CAUSES AND PREVENTION. By Frank N. Speller. Third edition. McGraw-Hill Book Company, New York, N. Y., 1951. 686 pages, charts, illustrations, tables, 9 1/2 by 6 1/2 inches, cloth, $10.00. Extensive revision and additions have been made in this edition which endeavors to give a comprehensive view of the subject. Technical detail has been restricted to that necessary for a sound understanding of the many factors involved in corrosion and the principles of corrosion prevention, mainly with relation to ferrous metals. Many references are included as footnotes but the general bibliography has been omitted from this edition.

THE DESIGN OF SWITCHING CIRCUITS. (The Bell Telephone Laboratories Series.) By William Keister, A. E. Ritchie, S. H. Washburn. D. Van Nostrand Company, New York, N. Y., 1951. 556 pages, charts, diagrams, 9 1/4 by 6 1/4 inches, cloth, $6.00. The object of this book is to present the fundamental principles underlying switching-circuit design rather than to describe the operation of specific circuits, except as examples. The subjects range from elementary concepts to the design of circuits containing a relatively large number of switching devices. Physical and electrical characteristics of switching devices are given, unifunctional circuits are discussed, and the last three chapters cover the synthesizing of such basic functional circuits into practical working systems. The circuits and techniques given are applicable to digital computers and other complex control systems as well as to telephone switching systems.

ELECTRICAL ENGINEERING. The Theory and Characteristics of Electrical Circuits and Machinery. By Clarence V. Christie. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Sixth edition, 1952. 675 pages, charts, diagrams, 9 1/4 by 6 1/4 inches, cloth, $7.00. Written primarily for students in the low-frequency power and industrial and electrical fields, this standard textbook presents, as well, an adequate basis for those particularly interested in the subjects of electronic control and communication engineering. The book has been revised in accordance with developments since the last edition, including descriptions of special types of d-c machines and various systems of speed control. Both d-c and a-c circuits and machines are covered.

EQUIVALENT CIRCUITS OF ELECTRIC MACHINERY. (General Electric Series.) By Gabriel Kron. John Wiley and Sons, New York, N. Y., 1951. 278 pages, charts, diagrams, 9 1/4 by 6 inches, cloth, $10.00. In this book equivalent circuits (stationary electric-circuit models) are developed for all rotating electric machines and groups of machines by means of a unified physical picture, without any mathematical analysis. The behavior of all types of machines or groups of machines is represented under all operating conditions that may be expressed in terms of constant, sinusoidal, or sums of sinusoidal currents and speeds. Short circuits, sudden load variations, and so forth, are covered as well as steady-state, constant-speed operation. Most of the circuits given appear in this book for the first time.

FUNDAMENTALS OF AUTOMATIC CONTROL. By G. H. Farrington. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1951. 285 pages, charts, diagrams, tables, 8 3/4 by 5 1/2 inches, cloth, $5.00. A general survey of a wide field, dealing with the underlying principles which affect automatic control performance rather than with the specific details of plant or apparatus. A thorough mathematical analysis is provided, and the formulation and use of analogies is considered. The final chapter deals briefly with the selection and adjustment of control systems.

FUNDAMENTALS OF ELECTRONICS. By F. H. Mitchell. Addison-Wesley, Cambridge, Mass., 1951. 243 pages, charts, diagrams, illustrations, 9 1/2 by 6 1/2 inches, cloth, $4.50. Intended for a one-semester course, this text deals with some of the more important fundamental phenomena and with selected illustrations of their applications. Two review chapters on d-c and a-c circuits precede the main material covering electron emission, electron tube types, and special electronic devices. A small folder which is included contains diagrams which will assist in the solution of problems involving graphical application of tube characteristic curves.

FUNDAMENTALS OF RADIO COMMUNICATIONS. By Abraham Sheingold. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 10, N. Y., 1951. 442 pages, charts, diagrams, illustrations, 9 1/4 by 6 inches, cloth, $5.25. The purpose of this book is to present, in sufficiently comprehensive form for basic understanding, the principles and techniques employed in modern radio-communication systems. The text material covers general methods, capabilities, and limitations; it considers in detail the important characteristics of basic components and circuits; and it deals practically with the operational features of such radio systems as amplitude-modulated and frequency-modulated sound-communication systems, television,

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ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

facsimile, multiplex systems, radar, and loran. The treatment is on an intermediate academic level.

GENERATING STATIONS. Economic Elements of Electrical Design. By Alfred H. Lovell. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Fourth edition, 1951. 431 pages, charts, diagrams, illustrations, tables, $9^1/_4$ by $6^1/_4$ inches, cloth, $6.50. The application of economic principles to the problems of the design of generating stations and transmission systems is described. The selection and application of apparatus, the proportioning of details of the assembly, the balancing of initial and subsequent costs, and related topics are considered. The revised edition presents new material on the gas turbine and advanced designs in circuit breakers and relays and in generating-station auxiliaries. The intention is to give a solid basis for an understanding of the engineering features of the power industry as a whole.

HIGH FREQUENCY TRANSMISSION LINES (Methuen's Monographs on Physical Subjects). By Willis Jackson. John Wiley and Sons, Inc., New York, N. Y., third edition, 1951. 152 pages, diagrams, $6^3/_4$ by $4^1/_4$ inches, cloth, $1.75. This small book dealing with transmission-line theory considers the characteristic properties of lines and analyzes their applications in high-frequency technique. Restrictions associated with such applications are discussed, however, to demonstrate that, while highly useful in this way, normal transmission-line theory is simply a guide to probable performance.

THE HIGH PRESSURE MERCURY VAPOUR DISCHARGE (Selected Topics in Modern Physics II). By W. Elenbaas. North-Holland Publishing Company, Amsterdam, The Netherlands, 1951. 173 pages, charts, tables, diagrams, illustrations, 9 by 6 inches, cloth. Available in the United States from Interscience Publishers, Inc., New York, N. Y., $4.00. A general survey of the theory of the high-pressure mercury vapor discharge as it now stands after some 20 years of development concurrent with the development of light sources utilizing these discharges. The detailed treatment provides a thorough mathematical analysis of the electronic, thermodynamic, radiational, and spectrographic aspects. There is a considerable list of references.

INSPECTION AND GAGING. By C. W. Kennedy. Industrial Press, New York, N. Y., 1951. 502 pages, charts, diagrams, tables, illustrations, $9^1/_4$ by $6^1/_4$ inches, cloth, $7.50. This comprehensive training manual and reference work discusses the place of inspection in industry, describes the types of automatic and manual gauging and measuring devices employed, shows the proper techniques of using inspection equipment, and outlines the specific duties of inspection personnel. The detailed descriptions and instructions are illustrated by numerous photographs and line sketches.

INVENTIONS AND THEIR MANAGEMENT. By Alf K. Berle and L. Sprague De Camp. International Textbook Company, Scranton 9, Pa. Third edition, 1951. 742 pages, diagrams, illustrations, $8^1/_2$ by $5^1/_2$ inches, cloth, $7.50. This comprehensive standard work presents the principles and practices governing the technical, legal, and business procedures of invention, from the history and theory of the protection of ideas to the methods of exploitation. Numerous illustrative cases from actual experience are given. Foreign patents, trade-marks, and copyrights are discussed, patent drafting is considered briefly, and a glossary and detailed index are included.

LEXIKON DER ELEKTROTECHNIK. By Gunther Oberdorfer. Springer-Verlag, Wien, Austria, 1951. 488 pages, illustrations, diagrams, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $4.80. This double-purpose dictionary provides the English and French equivalents for German words in the electrotechnical field, and also German definitions, for all but the commonest terms, ranging from single sentences to two full pages in the case of topics such as transformers, rectifiers, grid control, amplifying tubes, and so forth. The book is illustrated, and provides alphabetical lists of the English and French terms used in the main part.

LIGHT, PHOTOMETRY, AND ILLUMINATING ENGINEERING. By William E. Barrows. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Third edition, 1951. 415 pages, charts, diagrams, illustrations, tables, $9^1/_4$ by $6^1/_4$ inches, cloth, $7.50. This new edition presents, as before, material on the various types of lamps, illumination levels, utilization factors of luminaires and design data, together with the method of procedure in applying this material to the design of lighting installations. Approximately two-thirds of the material in the present edition is new or completely revised and now includes fluorescent lamps.

MAGNETIC AND ELECTRICAL METHODS OF NON-DESTRUCTIVE TESTING. By D. M. Lewis. (Report prepared for the Magnetic and Electrical Methods Sub-Committee of the British Iron and Steel Research Association.) George Allen and Unwin, Ltd., London, England, 1951. 242 pages, charts, diagrams, illustrations, $8^3/_4$ by $5^1/_2$ inches, cloth, 35s. Intended as a reference work rather than a text, this book gives detailed information on equipment and methods. Part I deals with magnetic particle testing for crack detection, including methods of magnetising, interpretation of indications, demagnetisation, and so forth. Part II covers other methods of crack detection: d-c search coil; a-c and radio-frequency methods; electrical resistance. Part III describes magnetic and electrical methods of measuring plate and coating thickness, and Part IV covers magnetic, electrical, and electronic sorting methods. An extensive bibliography is appended.

MAINTENANCE AND SERVICING OF ELECTRICAL INSTRUMENTS. By James Spencer. The Instruments Publishing Company, Pittsburgh, Pa., third edition, 1951. 256 pages, illustrations, diagrams, 8 by $4^1/_2$ inches, cloth, $3.00. This manual contains practical information on the maintenance and repair of all kinds of electric indicating instruments. The instructions are detailed and are illustrated by many photographs and drawings. There is a chapter on pivots and bearings. Users of instruments, as well as repairmen, will find the book useful. The revision in this edition consists of changes in the photographic illustrations; text and diagrams are the same.

MANUAL FOR THE ILLUMINATING ENGINEER ON LARGE SIZE PERFECT DIFFUSORS. By H. Zijl. N. V. Philips' Gloeilampenfabrieken (Philips Industries), Eindhoven, The Netherlands, 1951. 196 pages, charts, tables, diagrams, $9^1/_4$ by $6^1/_4$ inches, cloth. Available in the United States from Elsevier Press, Inc., Houston, Tex., $4.25. This work is a survey of the problems of light distribution for diffuse emitters of both finite and infinite dimensions. The mathematical formulae recommended for practical use are clearly set forth, and for those interested in the theoretical basis the author shows how they are derived and thus indicates the way to further study. Daylight control is covered as well as artificial sources. The large number of illustrative and practical sketches and graphs includes a set of 49 charts for direct computation of illumination values.

NATIONAL ELECTRIC CODE HANDBOOK. By Arthur L. Abbott. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Seventh edition, 1952. 652 pages, diagrams, illustrations, tables, $7^3/_4$ by $5^1/_4$ inches, cloth, $6.00. Dealing with many questions on materials, plans, wiring, and installation, this volume is a practical reference book covering the 1951 National Electrical Code. There are six divisions: Part I consists of definitions; Part II is devoted to the 15 types of wiring for use in light and power wiring systems; rules for installation are in Part III; requirements for installation, such as rules for services, grounding, automatic overcurrent protection, and wiring installation design are grouped in Part IV; Part V deals with special cases; and all specifications for the construction of materials, devices, apparatus, and equipment are placed in Part VI. Also in this last section are such tables as those of simplified data applying to the wiring of all ordinary motors.

THE OXIDE-COATED CATHODE, Volume 1: Manufacture; Volume 2: Physics. By G. Herrmann, translated by S. Wagener. Chapman and Hall, Ltd., London, England, 1951. 148 pages, 311 pages, illustrations, charts, tables, diagrams, $8^3/_4$ by $5^1/_2$ inches, cloth, volume 1: sh.21/-, volume 2: sh.42/-. An English edition of a work first published in Germany in 1944. In the process of translation it was found possible to incorporate developments in the field subsequent to that date. Volume 1 begins with a historical review and a discussion of different types and their applications. This is followed by a description of the manufacturing processes and of the cathode characteristics. The final section deals with certain special types of cathodes. Volume 2 provides a review of the physical phenomena of oxide cathodes, broadly classified under the following headings: thermal emission of electrons from metals; methods of measuring the work function of metals; phenomena in ionic solids; mechanism of emission from an activated oxide coating in equilibrium; variations in the equilibrium of the oxide coating; and oxide coatings of different compositions.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

NEMA Standards for Unit Substations. This publication covers integral primary unit substations and radial-type, primary-network-type, spot-network-type, low-voltage selective-type, and duplex-type articulated primary unit substations. Specific information is given concerning general arrangement, transforming section, outgoing section, and additional and alternate standard equipments. The different types of units are defined and 1-line diagrams illustrate typical substation units. $3.00 per copy. Publication Number *201-1951* to *205-1951*. Available from the National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.

Research Directed Toward the Development of Acclimatized Silver Halide Film. Describes cellulose film bases that meet these requirements: good dimensional stability, optical clarity, low moisture absorption, constancy of composition, and good aging qualities over the entire temperature range from −65 degrees Fahrenheit to 140 degrees Fahrenheit, and ease of fabrication. New film compositions, production processes, and testing methods are described. $8.75 in photostat, or $3.00 in microfilm form. Obtainable from: Library of Congress Photoduplication Service, Publication Board Project, Washington 25, D. C.

Development and Application of Barium Titanate Ceramics as Nonlinear Circuit Elements. The possibility that ceramic (crystalline barium titanate) materials will replace vacuum tubes as amplifiers in electronic circuits is indicated by this Signal Corps development report. A study of this material at high frequencies revealed that it had a high dielectric constant which varies with applied alternating voltage; hence it could be used to produce amplification in electronic circuits. Available for $2.50 in microfilm and $5.00 in photostat from the Library of Congress Photoduplication Service, Publication Board Project, Washington 25, D. C.

The Modern Gas Engine. This paper was presented at the Oil and Gas Power Conference of The American Society of Mechanical Engineers. Contains data, photographs, and charts on the development of the large internal combustion engines used for pipe line transmission service and electric power generation. Discusses also the installation and operating economies of different types of design on their services. Available from The Copper-Bessemer Corporation, Mount Vernon, Ohio.

The Edison Effect. This booklet is second in a series of case histories on Thomas A. Edison's principal inventions and their development into major American industries. The beginnings of the electronics industry are dealt with in this booklet. 50¢ per copy. Available from Thomas Alva Edison Foundation, Lakeside Avenue, West Orange, N. J.

INDUSTRIAL NOTES ....

RCA Elections. David S. Rau has been elected Vice-President and chief engineer and C. W. Latimer has been made Vice-President and chief technical consultant of RCA Communications, Inc. The Radio Corporation of America has also announced the election of Edwin Dorsey Foster as Vice-President and director of planning for their RCA Victor Division.

United States Steel News. The United States Steel Corporation has announced the following appointments: C. D. King has been made Assistant Vice-President and Chairman, engineering committees; J. Donald Rollins has been named Assistant Vice-President, engineering; and Nelson W. Dempsey has been appointed assistant manager of operations of the Chicago district of the company's Cuyahoga Works. Clyde B. Colwell, Jr., has been named district manager, Twin Cities District, United States Steel Supply Division; he succeeds John K. Rittenhouse, who died recently.

W. E. Ruder Retires from G-E. William E. Ruder, a leading authority in the field of permanent magnets and magnetic materials, has retired from the General Electric Company's research laboratory after more than 44 years of service. His most recent post was that of manager of the laboratory's Metallurgy Research Department.

The General Electric Company has also announced the following new appointments in their small appliance division: Alton P. Boulton as manager, appliance service centers; William K. Skofield, manager of advance engineering, vacuum cleaner and fan department; James P. Hunter, manager of engineering, and Peter W. Cherry and Rudolph H. Koepf, manager and assistant manager, respectively, of appearance design.

Top Level Advancements at Philco. In a move to broaden their divisionalization program, the Philco Corporation has announced the following top level advancements: John M. Otter has been made Vice-President and general manager, refrigeration division; Thomas A. Kennally has been named Vice-President on the executive staff and Chairman of the distribution committee; Raymond B. George has been appointed Corporate Vice-President of merchandising; Frederick D. Ogilby has been made Vice-President, television and radio division; and Martin F. Shea has been appointed Vice-President, auto-radio division.

Sylvania Purchases Two Electrical Concerns; Appointment. Sylvania Electric Products, Inc., has purchased the assets of the A. W. Franklin Manufacturing Corporation and the Franklin Airloop Corporation, both of Long Island City, N. Y. Sylvania will continue to operate them in their present location as a unit of its parts division, manufacturing the same electronics products, but will expand the unit production considerably. A. W. Franklin, founder and president of both companies, will act as general manager. Sylvania has also announced the appointment of Lewis Gordon as managing director of their international division.

Carbide and Carbon Expands Texas Plant. Construction of a major unit for the production of polyethylene resins has been announced as an addition to the Texas City, Tex., plant of the Carbide and Carbon Chemicals Company, a division of the Union Carbide and Carbon Corporation.

Van Horn to Direct Research at Alcoa. Dr. Kent R. Van Horn, a leading research metallurgist and authority on industrial X ray, has been made Director of Research, Aluminum Company of America. Dr. Van Horn succeeds Dr. Francis C. Frary, who is retiring. The company has also announced the retirement of John W. Schreiber, chief construction engineer. He is being succeeded by L. B. Kuhns.

$1,800,000 Reliance Plant in Operation. The new $1,800,000 Euclid, Ohio, plant built by the Reliance Electric and Engineering Company has been put into operation and the firm's engineering, development, research, renewal parts, and tool departments have moved into the new facility from the firm's two former plants in Cleveland.

Dahlstrand Retires from Allis-Chalmers; Appointment. Hans P. Dahlstrand, ranking American steam turbine engineer, has retired as director of steam turbine engineering at the Allis-Chalmers Manufacturing Company. The company has also announced the appointment of William M. Wallace as assistant to the Vice-President of the general machinery division.

Leeds and Northrup Opens New Office. The Leeds and Northrup Company has opened a new sales and service office at 3084 Grandview Avenue, Atlanta 5, Ga. William A. Macan is manager.

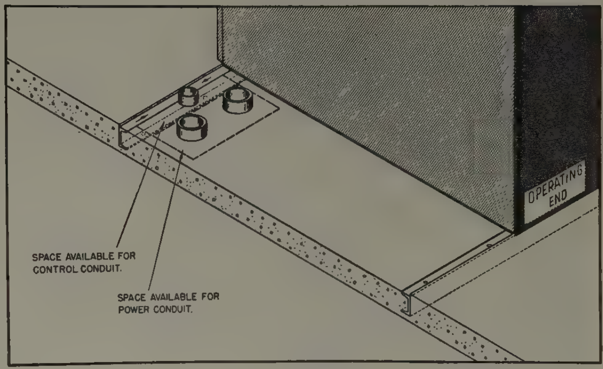
Aluminium Ltd. Plans 150-Per-Cent Jamaican Expansion. To help meet defense needs for aluminum in the United States and other nations of the free world, a 150-per-cent expansion of Aluminium, Ltd.'s bauxite-alumina production facilities in Jamaica, involving an additional Canadian investment of at least $20,000,000 in the Caribbean area, is now under construction. Under the new program, the company's alumina plant, first in the Caribbean, will have its planned capacity increased from 200 short tons to 500 tons of alumina per day, with a further enlargement to 740 tons per day as a successive development. To service the plant and handle export shipments, a deep-sea port will be created on the south coast of Jamaica in Old Harbour Bay. Total

(*Continued on page 24A*)

PROVES ITS ENGINEER APPEAL

CONSTRUCTION ENGINEERS

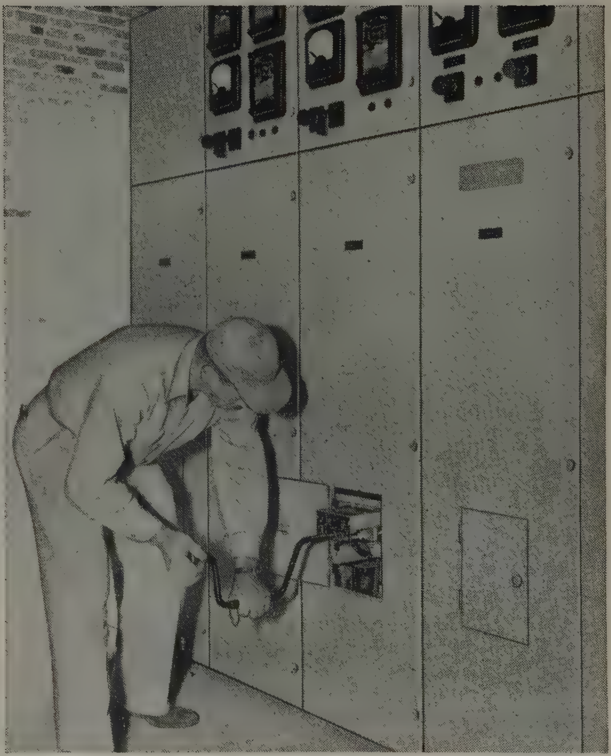
I-T-E provides switchboard floor plans, front view drawings and single line diagrams well ahead of shipment. When you're ready, I-T-E forwards channel bases—your equipment goes in right on schedule! Control and primary cables can enter structure at top or bottom. Control cable connections are located just inside the removable rear panel. You have them completely accessible for inspection and checking *without* de-energizing the circuit, *without* removing the breaker, *without* entering the switchgear structure.



OPERATING ENGINEERS

Important operating advantages of I-T-E Metalclad Switchgear save steps and guard your safety. Here are just a few of them:

1. Secondary circuit testing without removal of breakers from the stationary structure. No separate operation of secondary disconnecting devices is required.
2. The double interlock assures complete safety of personnel and equipment—guards against improper insertion or withdrawal of the circuit breakers. Interlocks are built into the circuit breaker—eliminating complicated engagement mechanisms between the breaker and structure. Adjustments are simplified and interchangeability is assured.
3. Circuit breaker control-relay is mounted on breaker truck; (when breaker comes out, relay comes out. No "climbing" into structure to inspect control-relay).
4. Truck-mounted horizontal removable elements eliminate hours of maintenance usually required for complicated elevator mechanisms.



Full operating positioning is accomplished by mechanical racking.

Specify I-T-E **METALCLAD SWITCHGEAR**

I-T-E CIRCUIT BREAKER CO. • 19th & HAMILTON STS. • PHILA. 30, PA.

R&IE Equipment Division, Greensburg, Pa. • Canadian Mfg. & Sales: Eastern Power Devices, Ltd., Toronto • Export Sales: Philips Export Corp., N.Y. 17, N.Y.

(*Continued from page 16A*)

investment may go as high as $40,000,000, including the cost of extensive agricultural projects initiated 6 years ago. The program is being carried out by Jamaica Bauxites, Ltd., fully owned subsidiary of Aluminium, Ltd. All capital requirements are being provided by the parent company, with the exception of $6,700,000 towards the cost of the first stage plant, which was loaned to Jamaica Bauxites, Ltd., by the Mutual Security Agency. The loan is being repaid by aluminum shipments to the United States Government stockpile.

Westinghouse News. Limited production and the beginning of gradual employment at Westinghouse Electric Corporation's new small motor division plant at Union City, Ind., has begun. A scarcity of critical materials and the necessity of training each new employee individually advanced the opening date somewhat. The corporation has also officially opened a new lamp sales and warehouse building in Dallas, Tex.

Recent appointments announced by Westinghouse are those of George W. Jernstedt, made manager of engineering, special products development division, and George E. Goodrich, named assistant manager, Industrial Department, apparatus division.

G-E Gets $6,000,000 Order from Indonesia. A $6,000,000 order for 27 diesel-electric locomotives has been placed with the International General Electric Company, Inc., by the Indonesia State Railways. The locomotives are expected to aid Indonesia's economy by providing better rail transportation for the country's rubber and tin exports.

Sylvania Signs Contract with Atomic Energy Commission. The United States Atomic Energy Commission has contracted with Sylvania Electric Products, Inc., for an expanded program of research and development in the field of nuclear reactor materials. The work will be carried out by Sylvania's Atomic Energy Division, under the direction of Walter E. Kingston, formerly manager of the company's metallurgical laboratories.

National Bureau of Standards Appointment. Edward C. Lloyd has been appointed assistant chief of the National Bureau of Standards' Office of Basic Instrumentation.

Delta-Star Expansion. Plans have been announced for a $500,000 plant expansion program at the Delta-Star Electric Company, Division of H. K. Porter Company, Inc.

Sprague Opens Los Angeles Engineering Offices. Establishment of a Pacific Coast application engineering office and radio noise suppression laboratory to better serve the electronics and aircraft industries

(*Continued on page 32A*)

(*Continued from page 24A*)

of Southern California has been announced by the Sprague Electric Company. Manager of the new office is Thomas S. Bills. The company has also appointed Frederick W. Reynolds, Jr., to the application engineering staff of their New York office.

Weston Names Three Sales Executives: Philip Barnes has been appointed director of the sales division and Hubert M. Ricks has been made general sales manager of the Weston Electrical Instrument Corporation.

NEW PRODUCTS • •

Gas Switching Tubes. A small gas switching tube (it resembles a miniature cigarette lighter) for microwave applications in military and commercial radar has been developed by the General Electric Company's Tube Department. The new tube acts as a switch to decouple the transmitter from a common transmitting and receiving antenna to allow the antenna to receive the return signal after a radar signal has been transmitted. Speed is essential to attain full sensitivity of the system for near-by objects. The tube, number *GL6038,* cuts recovery time, key factor in viewing objects at close range, to only 8 microseconds at a power of 50 kw, with a pulse repetition rate of 1,000 pulses per second, and a pulse switch width of 0.5 microsecond, at 9,300 megacycles. It can be used in equipment having a maximum transmitting power of 100 kw, and will operate within a frequency range of 9,000 to 9,600 megacycles. Characteristic data and other information on the new *GL6038* may be obtained from the Tube Department, General Electric Company, Electronic Division, Schenectady 5, N. Y.

Electron Microscope. The North American Philips Company, Inc., 750 South Fulton Avenue, Mount Vernon, N. Y., has announced development of a new electron microscope with a continuous screen magnification from 1,000 times to 60,000 times. The instrument is capable of producing micrograms of 30 angstroms' resolution or better. Accelerating potentials of 40, 60, 80, and 100 kv are available The microscope has a beam oscillator for rapid determination of exact focus, eliminating the necessity for a series of exposures with conjunctive time loss. The unit has an extremely large field and permits recording in a single photograph areas which might otherwise require a mosaic of six individual sections. A roll film camera is employed, using standard 35-millimeter high contrast film, permitting up to 40 exposures at one loading and allowing grain-free enlargements to 12 times or better. Positioning and film transport are effected instantaneously while under vacuum and partial exposure of the magazine is possible. A built-in photometer provides a standard

(*Continued on page 38A*)

Admiral TV

Picture Tube Leads are insulated with

NATVAR 400

EXTRUDED PLASTIC TUBING

In this Admiral Model 121 K 16 TV with 20″ picture tube, the 2nd anode lead from the high voltage rectifier carries 12,500 volts to the picture tube. This important lead is insulated and protected with Natvar 400 Extruded Plastic Tubing.

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Natvar Products

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- Varnished identification markers
- Lacquered tubing and sleeving
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Ask for Catalog No. 22

Admiral Corporation, in the past decade, has grown to be one of the largest and best known makers of TV and Radio Sets and Electrical Appliances. Leaders in research, design, and engineering, they have succeeded by offering *quality* merchandise at the lowest possible price.

To safeguard this quality, Admiral is extremely careful in the selection of component parts and materials. They use Natvar 400 Extruded Plastic Tubing because of its excellent electrical and mechanical properties, and because it is dependably uniform.

Natvar 400 and other Natvar flexible electrical insulating materials are available either from your wholesaler's stock or direct from our own.

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(*Continued from page 32A*)

for proper exposure time. Immediate changeover for electron diffraction patterns of preselected portions of the specimen is possible without change of pole pieces, specimen transferral, or re-evacuation. The unit requires 3-phase 4-wire 220- to 380-volt 60-cycle supply, with neutral wire and the usual equipment ground lead. Power consumption is $2^1/_2$ to 3 kva. Conversion transformers are available for 230-volt delta or 120- to 208-volt star systems. Cooling water of approximately 60 degrees Fahrenheit and flowing at a rate of 2 quarts per minute with a pressure of 15 to 20 pounds per square inch is required. Provision must be made for handling the discharge water. The North American Philips Company will supply any further information.

Power Level Recorder. Product of 10 years of research and development, the Leeds and Northrup power level recorder affords continuous, automatic recording of power-level measurements in electronic development work. Recording of antenna patterns, attenuation of transmission lines, and characteristics of filter networks can be accomplished in a matter of minutes. The recorder measures and continuously records power level by attenuating the input signal to match a constant, internal reference voltage. Depending on requirements, full-scale reading is 20, 30, 40, 50, or 60 decibels above a reference level of 0.002 milliwatt. The reference level can be adjusted manually by approximately ±5 decibels. Full-scale changes of power level are recorded in less than 2 seconds. Limit of error is ±5 per cent of full scale within the frequency range of 40 to 150,000 cycles. An outstanding feature is a square-law detector which handles an input composed of two or more components of different frequency in such a way that their relative phase angles have no effect on the mean detector output. For information, write the Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pa.

Projection Oscilloscope. The model *T-602* projection oscilloscope developed by the Television Equipment Corporation, 238 William Street, New York 38, N. Y., makes waveform demonstrations brilliantly clear to groups as large as 750 persons. Employing a projection-type cathode-ray tube with electrostatic deflection, the unit provides two types of projection images. For direct viewing it has an 18 by 18 by 24-inch integral screen upon which the patterns are projected from the rear. For wall screen projection the integral screen slides back and images 8 by 10 feet or larger are available. The vertical amplifier has a response within 3 decibels from 2 cycles to 825 kc per second at a sensitivity of 1 millivolt rms per inch on the integral screen. Further information is available from the company.

Special Cathode-Ray Tubes. The Allen B. Du Mont Laboratories have made

(*Continued on page 42A*)

SILICONE PROGRESS

TO HARNESS HORSEPOWER—

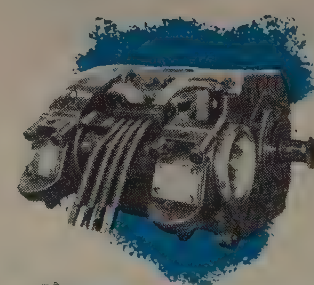
use G-E SILICONES for insulation

Exceptional heat resistance (up to 500 F) makes G-E silicone rubber ideal for insulation in harnesses for aircraft and automotive ignition systems.

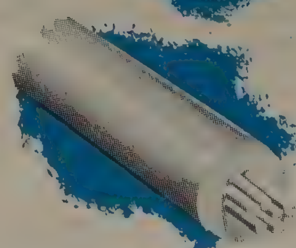
Now you can design electrical components which will operate over a wide temperature range—thanks to the unusual properties imparted to these products by General Electric silicones. Substantial reduction (25-40% on an average) in size and weight of transformers, generators, and other electrical equipment is also possible when G-E silicones are used in the insulation.

Have you considered G-E silicones in your products? Perhaps you need a resin or a varnish for bonding or impregnating purposes. Perhaps you need a resilient material for gaskets or sheeting. Or do you need a fluid to impart water-repellency to masonry surfaces? Whatever your need, it will pay you to investigate G-E silicones. You may find a ready answer to your problem.

OTHER EXAMPLES OF G-E SILICONE INSULATION

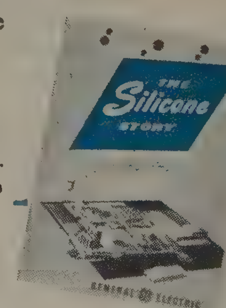


Save rewind costs—on heavy-duty motors because G-E silicones in "Class H" insulation withstand high heat and mechanical stress.



Higher operating temperatures for motors, generators, and transformers require flexible lead wires insulated with G-E silicones.

Want more information? More examples of G-E silicone developments of importance to industry are to be found in *The Silicone Story*. Send the coupon today for *your* free copy.



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G-E SILICONES FIT INTO YOUR FUTURE

GENERAL ELECTRIC

(*Continued from page 38A*)

available a broad range of special cathode-ray tubes for highly specialized applications. Typical of these special tubes is the type *K1052*, a 7-inch electrostatic tube containing five wholly independent electron-gun and deflection-electrode structures in a single glass envelope. Simple connection to all deflection electrodes of this tube is assured by an auxiliary ring-socket at the neck. The electron gun and deflection structures are shielded carefully to minimize interaction between channels. Another tube is the type *K1101P*, a 5-inch electrostatic tube designed for ultra-high-speed oscillography. Operated at accelerations up to 37,000 volts, type *K1101P* will present usable displays of frequencies as high as 1,000 megacycles. Complete specifications on these and other special tubes are available from Mr. G. Robert Mezger, Allen B. Du Mont Laboratories, Inc., 1000 Main Avenue, Clifton, N. J.

D-C Disconnecting Switch. A 2,000-ampere a-c or 3,000-ampere d-c disconnecting switch for potline or cell-cutout applications up to 250 volts is announced by the R & IE Equipment Division of the I-T-E Circuit Breaker Company, Greensburg, Pa. Originally developed as a short-circuiting switch for electrolytic cells, the switch is also applicable to electroplating and furnace busses, and so forth, wherever high-current, low-voltage switching is necessary. The switch normally is supported from the terminals, and as many as 16 units are connected together and operated from a single operating handle. These may be connected in parallel to form a single-pole, single-throw switch, or various units may be connected to form a 2-pole or 3-pole single or double-throw switch. Since the shaft is at bus potential when the switch is closed, operating links connecting the various shafts of a multi-pole switch are made of an insulating material. Rotation of the shaft closes the switch by engaging four self-aligning bridging contacts directly between the terminals. Contact is made and broken with a high-pressure wiping action to remove any dirt or corrosion from the contact surfaces. The shaft is steel and the base and bearing plates are steel for d-c switches, aluminum for a-c switches. This switch is not designed to open load currents, except in parallel with an electrolytic cell where the voltage drop across the cell is less than 10 volts. The R & IE Equipment Division will supply any further details.

Copper- and Aluminum-Clad Plastics. Two grades of laminated phenolic (*T-725* and *T-812*) are now being offered as copper-clad and aluminum-clad sheets by The Richardson Company, 2765 Lake Street, Melrose Park, Ill. These metal-clad laminates can be printed and etched to produce printed circuits for use in radio, television, and other electrical assemblies The metal foil is bonded to the laminate under heat and pressure and provides

(*Continued on page 46A*)

Only a complete line

answers *all your* electrical measuring requirements

The case of Mastic Tile Corporation demonstrates how the complete line of Westinghouse Instruments holds answers to your electrical measurement problems.

Mastic's problem was one of predetermining load on a Banbury Mixer motor in order to facilitate the operator's job and speed the mixing cycle. It was answered by the standard Westinghouse GY-40 Recording Wattmeter with proper choice of scale, current and potential transformers, and chart speed. In fact, so well did this standard instrument accomplish its job that final results show—a 15 percent reduction in mixing cycle time along with the elimination of damaging surge shocks which can now be anticipated and prevented by the machine operator.

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Competent Application Assistance!

Westinghouse Instrument Application Engineers are available to help you in selecting and applying the proper instruments for your application. Simply call your nearest Westinghouse office.

For complete information about Westinghouse Instruments write for Booklet B-4696, address: Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40407

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Westinghouse

WESTINGHOUSE

INSTRUMENTS

(*Continued from page 42A*)

high bond strength for this class of material. They can be punched, sawed, drilled, and otherwise machined. Additional information is available from the company.

High-Speed Vacuum Tubes. Two high-speed vacuum tubes designed for use in electronic systems utilizing vacuum tubes in place of stepping switches have been introduced by the International Standard Trading Corporation, an associate of the International Telephone and Telegraph Corporation. Developed in London, these tubes are the unidirectional cold-cathode decade counter (type *G10/240E*) and the primed cold-cathode trigger (type *G1/370K*). The cold-cathode unidirectional gas tube counter has 10 cathodes to indicate the number of the count, either visually at low speeds or by means of the voltage developed across the cathode load at high speeds. It is capable of counting pulses at repetition speeds between 0 and 20 kc. On every tenth pulse it provides a voltage output that is sufficient either to operate a coupling tube to the next counter stage or a registering circuit. This tube has been designed so that at low speeds it is possible to view the discharge directly and thus obtain a direct indication of the count. Development of the high-speed primed cold-cathode trigger tube became necessary with the advent of the cold-cathode decade counter for which a single cathode trigger tube is required as a coupling element between tubes. Its speed and general characteristics, however, make it a useful general component. Further information on these tubes may be obtained from the International Telephone and Telegraph Corporation, 67 Broad Street, New York 4, N. Y.

High-Speed Tape Reader. Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y., has designed a high-speed tape reader which can read 5-digit teleprinter tape at a maximum speed of 250 characters per second. A signal is emitted from the reader as soon as the information from the character is available, and the tape then may be stopped so that the information from that character continues to be available. If the tape is stationary on a character, then the next character is available for reading 5 milliseconds after the start signal. Cathode followers are incorporated in the tape reader for transmitting the output from the photocells used for detecting the information contained on the tape. The output voltage swing between 'hole' and 'no hole' is in excess of 12 volts. Three input supplies are required: 115 volts, 60 cycles, 80 watts for the motor and lamps; 300 volts d-c, 65 milliamperes: and −150 volts d-c, 50 milliamperes for the photoelectric system and cathode followers. Further information of the tape reader may be obtained from Ferranti Electric, Inc.

Varicons. Elco Corporation has introduced miniature connectors called Vari-

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cons which are rated at 30 amperes at 100 volts, withstanding voltage between closest terminals of 4,000 volts. Voltage is rated at 1,330 volts. Using only four basic components, it is possible to assemble male and female connectors with any required number of contacts. The connectors can be furnished assembled by Elco or can be put together by the user to suit his own requirements. Contacts, in assembly, are sandwiched between the end and middle body sections and it is the combinations or multiples of the sections used which provide the keying variations and flexibility which are features of this connector system. Contact resistance is 0.001 ohm; contact spacing is suitable for 300-ohm lines; contacts are made of brass and phosphor bronze on berylium copper, all silver plated; and body sections are of molded phenolic in general purpose or mica-filled and alkyd resins. The Elco Corporation, 190 West Glenwood Avenue, Philadelphia 40, Pa., will supply any further details.

TRADE LITERATURE

Flexible Shaft Handbook. The S. S. White Industrial Division, 10 East 40th Street, New York 16, N. Y., have announced publication of the third edition of their Flexible Shaft Handbook. This 256-page reference manual contains full details on the construction, selection, application, and range and scope of flexible shafts in transmitting power and remote control. There is also an appendix of engineering tables. Copies of the handbook are available to designers, engineers, and purchasing agents who request their copy on company letterhead.

X-Ray Diffraction. A new 60-page catalogue, "X-Ray Diffraction and Geiger-Counter X-Ray Spectrometric Equipment," may be obtained upon request to the Research and Control Instruments Division, North American Philips Company, Inc., 750 South Fulton Avenue, Mount Vernon, N. Y.

Technical Ceramics. The American Lava Corporation has published a 48-page pictorial representation on the custom manufacture of technical ceramics. Copies may be obtained from the corporation at Chattanooga 5, Tenn., by request upon company letterhead.

Instruments and Valves Catalogues. The Brown Instruments Division of the Minneapolis-Honeywell Regulator Company, Station 40, Wayne and Windrim Avenues, Philadelphia 44, Pa., has issued three new catalogues: number *5000*, which describes the principal instruments, control devices, and related components manufactured by the Industrial Division of the company; number *9300*, which describes their line of radiamatic pyrometers; and number *1800*, which covers

(*Continued on page 74A*)

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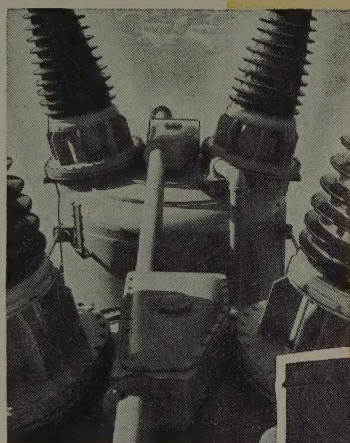

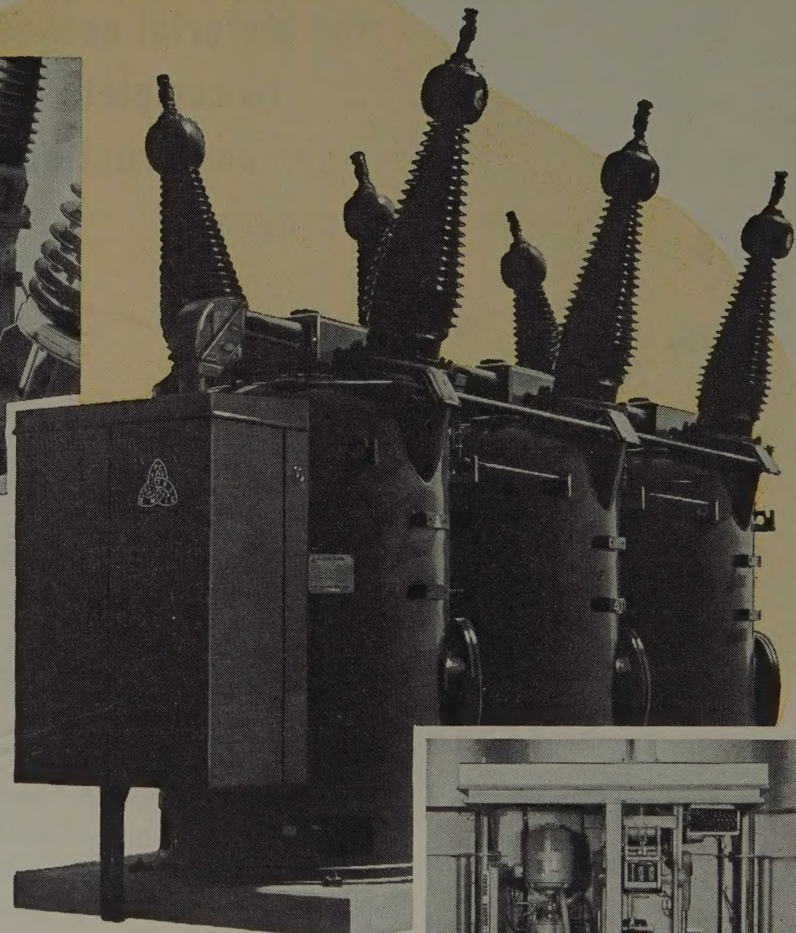

RIGHT: View of Tank Tops, looking toward Tank No. 1, showing housings for opening springs and tube containing pull rod.

CENTER: Type RHE in TEXAS (138 kv).

FAR RIGHT: Interior of Mechanism Cabinet, showing both closing-spring barrels and motor-operated oil-hydraulic jack for spring compression.

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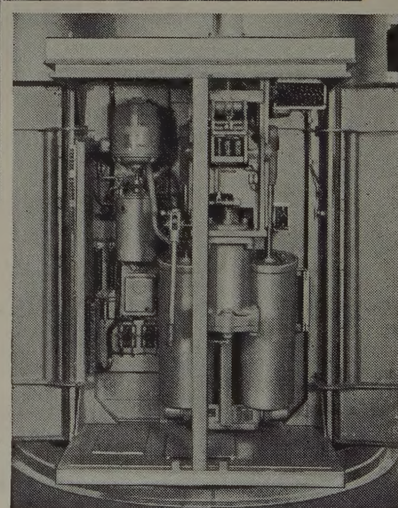

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(*Continued from page 60A*)

the use of Honeywell Air-O-Motor diaphragm operators with North American adjustable port valves. The catalogues may be obtained upon request.

Service Replacement Capacitors. Cornell-Dubilier Electric Corporation has released a new 28-page catalogue, number *200C*, which contains information on their service replacement capacitors for electronic and other applications. The corporation's Jobber Division, South Plainfield, N. J., will supply copies upon request.

Technical Data Books. Lefax Publishers, Philadelphia 7, Pa., has released its 1952 catalogue of pocket-sized technical data books. Over 2,000 subjects are listed. The catalogue is available upon request.

Copper and Copper Alloy Rods. A 24-page publication on copper and copper alloy rods for screw machine uses is available from The American Brass Company, Waterbury 20, Conn. Request publication *B-14*.

Electric Equipment for Arc Furnaces. Booklet *B-4695*, describing electric equipment for arc furnaces, may be obtained from the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

Nobotrons. A new catalogue giving full descriptions, ratings, and specifications of Sorensen and Company, Inc.'s, entire line of standard Nobotrons (electronically regulated d-c power sources) is available from the company at 375 Fairfield Avenue, Stamford, Conn.

Kinescopes and Television Servicing. The RCA Tube Department has published two new television data books: *RCA Kinescopes*, which contains detailed information on more than 100 different kinescope types now in use; and *Television Servicing*, a collection of special articles prepared by Radio Corporation of America's television authorities, John Meagher and Art Liebscher. Both are available from the Commercial Engineering Section of the RCA Tube Department, Radio Corporation of America, Harrison, N. J.: *RCA Kinescopes* for the price of \$0.25, and *Television Servicing* for the price of \$0.35.

Ceramic Bodies. Star Porcelain Company, Muirhead Avenue, Trenton, N. J., has released a 24-page brochure describing various ceramic bodies which are used principally in the manufacture of electric and electronic equipment. The brochure may be obtained upon request.

Home Wiring Estimator. A home wiring estimator which includes a lot of data essential when planning wiring systems has been announced by the Westinghouse Electric Corporation. For a copy of this home wiring estimator booklet *SA-6815*, send \$0.25 to Better Home Bureau, Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, Pa.